January 1965 Brief 65-10001

# NASA TECH BRIEF

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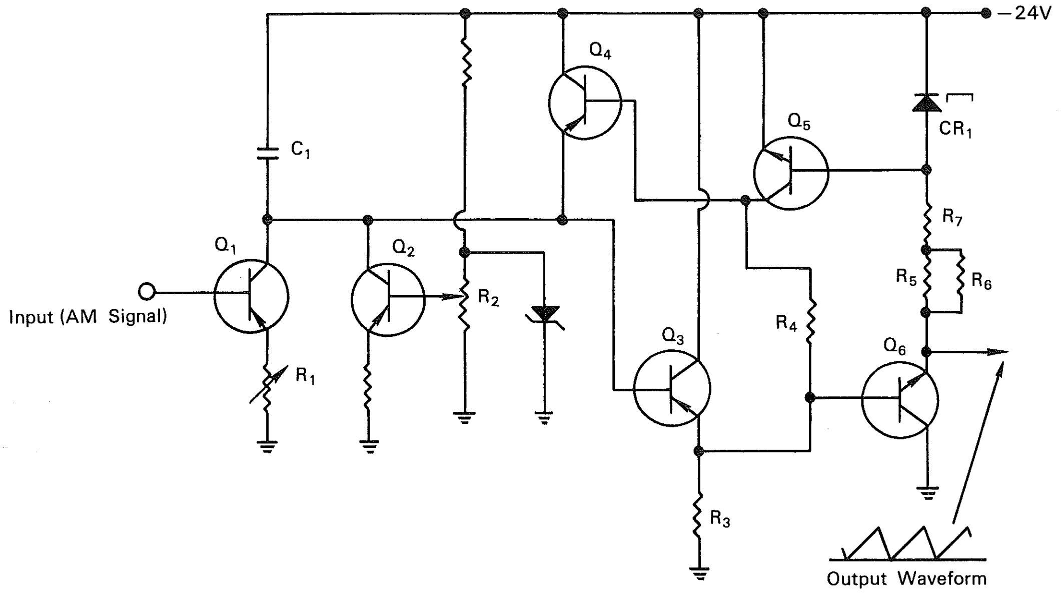
## Circuit Converts AM Signals to FM for Magnetic Recording



**The problem:** To find an improved method of converting AM signals to FM for magnetic recording. The new circuit should be less complex and more linear and reliable than existing methods.

**The solution:** A relaxation-type voltage-controlled oscillator (VCO) that produces a triangular output waveform at a frequency that is proportional (either directly or inversely) to the voltage of the varying AM input signal. A conventional multivibrator converts this triangular output waveform to a square-wave input to the recording device.

**How it's done:** Oscillation is produced in the circuit by the charging and discharging of the capacitor $C_1$. Its rate of charge, or frequency of oscillation, is controlled by current flow through $Q_1$ and $Q_2$. The current flowing in the collector circuit of $Q_1$ is proportional to the varying voltage (the AM input signal) across the base-emitter junction. Adjustment of $R_1$ controls the amount of deviation from its center frequency of the FM signal for a fixed input signal. The current flowing in the collector circuit of $Q_2$ provides a constant current source in addition to the varying source from $Q_1$. Varying $R_2$ adjusts the current through $Q_2$, thus controlling the center frequency of the VCO. $CR_1$ is a tunnel diode used to perform current sensing and switching. $Q_4$, $Q_5$, and $R_4$ discharge $C_1$ on signal from $CR_1$. $Q_3$, $Q_6$, and $R_3$ form an isolation amplifier to prevent the sensing and switching circuit from loading $C_1$. As $C_1$ charges, the voltage across it increases and appears across the series connection of the emitter-base junctions of $Q_3$ and $Q_6$,

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parallel resistors $R_5$ and $R_6$, $R_7$, and $CR_1$. $Q_5$ is held at cutoff by voltage divider $CR_1$, $Q_6$, $R_7$, $R_5$, and $R_6$. Direct coupling of $Q_5$ to $Q_4$ prevents $Q_4$ from discharging $C_1$. As the voltage across $CR_1$ exceeds its peak point, $CR_1$ switches to its high-resistance state causing current flow in the base-emitter junction of $Q_5$ and a corresponding increase in current flow in the collector circuits of $Q_5$ and $Q_4$. The drop in impedance at the collector of $Q_4$ discharges $C_1$. When the voltage across $C_1$ drops sufficiently, $CR_1$ switches to its low-resistance state and $Q_4$ is cut off. The triangular output waveform appears at the emitter of $Q_6$.

**Notes:**

1. This circuitry should be of interest to designers and manufacturers of radar, telemetry, and test equipment.
2. Inquiries concerning this innovation may be directed to:

   Technology Utilization Officer
   Goddard Space Flight Center
   Greenbelt, Maryland, 20771
   Reference: B65-10001

**Patent status:** NASA encourages commercial use of this innovation. No patent action is contemplated.

Source: Radio Corporation of America under
contract to Goddard Space Flight Center
(GSFC-227)

January 1965 Brief 65-10002

# NASA TECH BRIEF

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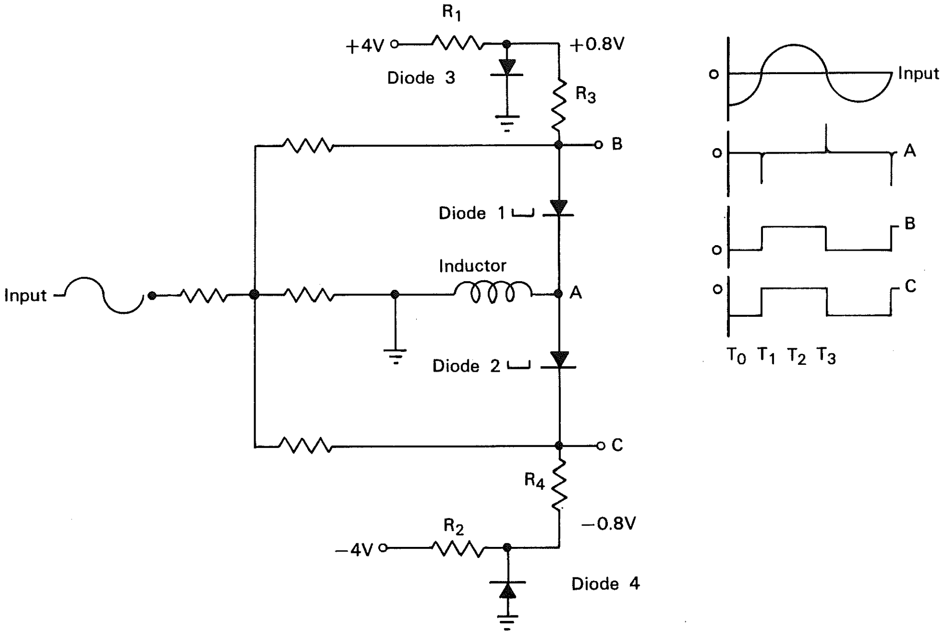
## Tunnel-Diode Circuit Features Zero-Level Clipping



**The problem**: Clipper circuits are used in a wide variety of applications. Often, clipping action must start as the input voltage crosses the waveform zero axis (positive-to-negative or negative-to-positive transition point). Conventional transistor and diode circuits have been designed for this function but generally fail to maintain the start of clipping at the zero point.

**The solution**: A tunnel-diode circuit that provides clipping action as the voltage crosses the zero axis. Separate outputs are provided for positive and negative clipping.

**How it's done**: At time $T_0$ the input voltage is negative, diode 1 is in the low-voltage/high-current state and diode 2 is in the high-voltage/low-current state. Both diodes are biased at their peak-point voltages. As the negative-input voltage moves towards positive, the current through diode 1 increases until at $T_1$ the peak-current value is reached and diode 1 switches to the high-voltage state. The rapid decrease in current through diode 1 causes a back emf to appear across the inductor. The negative pulse appearing at point A, due to the voltage developed across the inductor, causes diode 2 to switch to its low-voltage/high-current state and the output voltage at point C falls to the zero level. As the positive voltage (peak at $T_2$) decreases, the current through diode 2 will increase until, at $T_3$ which is at exactly input voltage zero, the peak current value of diode 2 is reached and it switches to the high-voltage/low-current state. At

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this time, $T_3$, the inductive voltage at A is positive and diode 1 switches to the low-voltage/high-current state. In this manner, diode 1 and diode 2 will switch to the opposite voltage/current state at every zero crossing (times $T_1$ and $T_3$) of the input voltage. Switching time is in the order of nanoseconds. The positive square waves which appear at B and the negative square waves which appear at C will rise and fall exactly coincident with the respective zero crossing of the input voltage regardless of the frequency, amplitude, or shape of the input signal, within the limits of circuit operation. Resistors $R_1$ and $R_2$ and diodes 3 and 4 provide the biasing and compensating circuits for the tunnel diodes. Resistors $R_3$ and $R_4$ are the load resistors for outputs B and C respectively.

**Notes:**

1. This circuit would be effective as a limiter in any FM receiver.
2. The circuit has been operated successfully over a wide frequency range and at temperatures from −50° to +70°C.
3. Inquiries concerning this invention may be directed to:

   Technology Utilization Officer
   Goddard Space Flight Center
   Greenbelt, Maryland, 20771
   Reference: B65-10002

**Patent status:** NASA encourages the immediate commercial use of this invention. Inquiries about obtaining rights for its commercial use may be made to NASA, Code AGP, Washington, D.C., 20546.

Source: Edgar G. Bush
(GSFC-241)

January 1965 Brief 65-10010

# NASA TECH BRIEF

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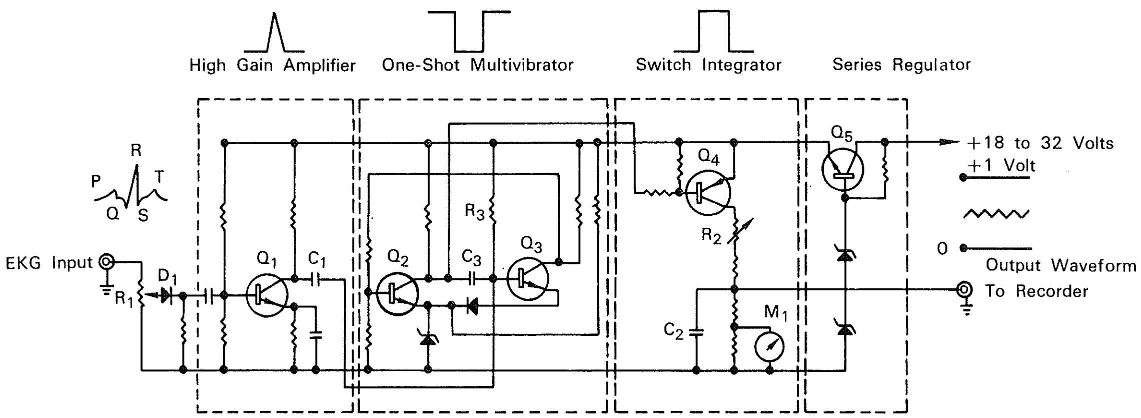
## Inexpensive, Stable Circuit Measures Heart Rate



**The problem:** Although circuits for measuring heart rate have been available for some time, they have either been more complex than basically necessary in order to accommodate a wide range of applications, or have been available only as part of an electrocardiograph (EKG) system. There is a need for a simple, inexpensive circuit that will provide a reliable indication of average heart rate.

**The solution:** An inexpensive, stable, transistorized circuit that provides an accurate analog indication of average heart rate in response to a preamplified EKG signal applied to its input. The device provides a meter indication of heart rate in addition to a proportional output voltage which may be fed to a high-input impedance recorder.

**How it's done:** The circuit uses the R-wave (positive spike) of an EKG signal to trigger a pulse generator. The metering circuit is basically an integrator which uses the constant-width, constant-amplitude pulses from the generator to produce a voltage proportional to the frequency of the pulses. The EKG input signal is applied across the trigger level control $R_1$ which is set so that $D_1$ passes only the large positive spikes (R-waves) of the signal. This spike is amplified by a high-gain, common emitter amplifier ($Q_1$ and associated circuitry) and then coupled to a one-shot multivibrator through $C_1$. The multivibrator ($Q_2$ and $Q_3$) produces a constant-duration, constant-amplitude, square-wave output for every input pulse from the amplifier. With no pulse present, $Q_3$ is conducting and $Q_2$ is cut off. Arrival of the negative pulse at the base of $Q_3$ decreases its collector current, producing a positive pulse at the base of $Q_2$. This causes an increase in the collector current of $Q_2$ and a corresponding negative shift of its collector voltage. This negative pulse is fed back to the base of $Q_3$ causing a rapid switch in the conditions of $Q_2$ and $Q_3$ ($Q_2$ turns on, $Q_3$ turns off). The pulse duration is determined by the $C_3R_3$ time constant after which $Q_2$ and $Q_3$ revert to their original states.

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The square-wave pulses from the multivibrator are coupled to the base of $Q_4$ which controls the average rate of current flow to the resistor-capacitor integrating network. An increase in the frequency of the square-wave signal causes an increase in $Q_4$'s collector current and a corresponding increase in the voltage across $C_2$. Output for a recorder with a high-input impedance (10,000-ohms minimum at 1 volt) is available directly across $C_2$. Resistor $R_2$ is adjusted to provide full-scale deflection of $M_1$ with an average heart rate of 200 beats per minute. An internal series voltage regulator is provided in the circuit for portable operation with batteries. If a constant voltage source is available, the regulator circuit ($Q_5$ and associated circuitry) may be omitted.

**Note:** Inquiries concerning this invention may be directed to:

Technology Utilization Officer
Manned Spacecraft Center
P.O. Box 1537
Houston, Texas, 77001
Reference: B65-10010

**Patent status:** NASA encourages the immediate commercial use of this invention. Inquiries about obtaining rights for its commercial use may be made to NASA, Code AGP, Washington, D.C., 20546.

Source: Howard A. Vick
(MSC-95)

January 1965 Brief 65-10011

# NASA TECH BRIEF

NASA Tech Briefs are issued by the Technology Utilization Division to summarize specific technical innovations derived from the space program. Copies are available to the public from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia, 22151.

## Circuit Improvement Produces Monostable Multivibrator with Load-Carrying Capability

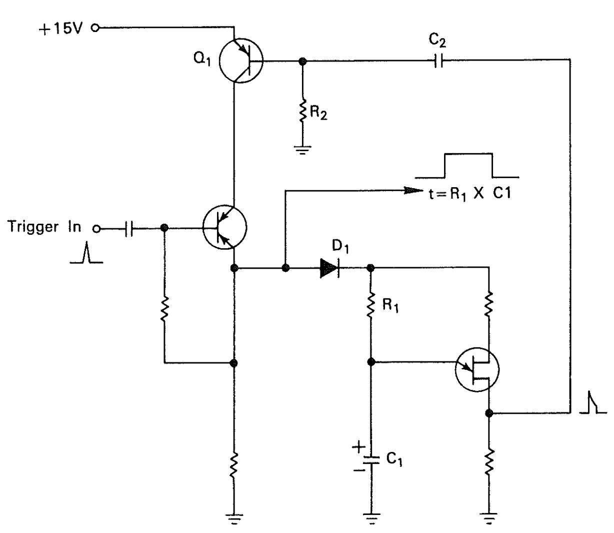

FIGURE 1

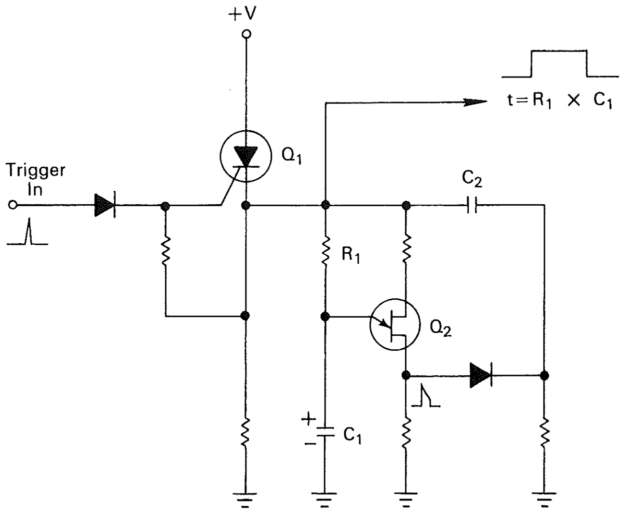

FIGURE 2

**The problem:** The circuit shown in figure 1 (U.S. Patent No. 3,085,165) is satisfactory for certain applications of light loading. If one is required to drive a heavy load from the cathode of $Q_1$, the biasing resistor $R_2$ must be of such a low value that circuit efficiency in standby would suffer. The reset capacitor $C_2$ would have to be so large that circuit cutoff by negative transients on the supply bus could occur.

**The solution:** Improvement of the circuit to provide greater reliability and load-carrying capability.

**How it's done:** In the circuit shown in figure 2, the reset transistor $Q_1$ and coupling diode $D_1$ (of figure 1) have been eliminated. This circuit is inherently insensitive to both positive and negative transients on the supply bus. It is more efficient when heavily loaded and has essentially zero standby current (the leakage current of $Q_1$). In this circuit, reset is accomplished by adding the low impedance output from base 1 of $Q_2$ to the cathode voltage of $Q_1$. This effectively back biases $Q_1$ and reduces the current to a value below its holding current. Coupling capacitor $C_1$ is large enough for the time constant R (effective load) X $C_2$ to sufficiently exceed the turn-off time of $Q_1$. A resistance at $R_1$ of 470K ohms and a capacitance at $C_1$ of 100 microfarads give a time interval of approximately 50 seconds.

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**Notes:**

1. The circuit has driven loads up to 150 ma over a temperature range of −30° to +80° C.
2. Inquiries concerning this invention may be directed to:

Technology Utilization Officer
Goddard Space Flight Center
Greenbelt, Maryland, 20771
Reference: B65-10011

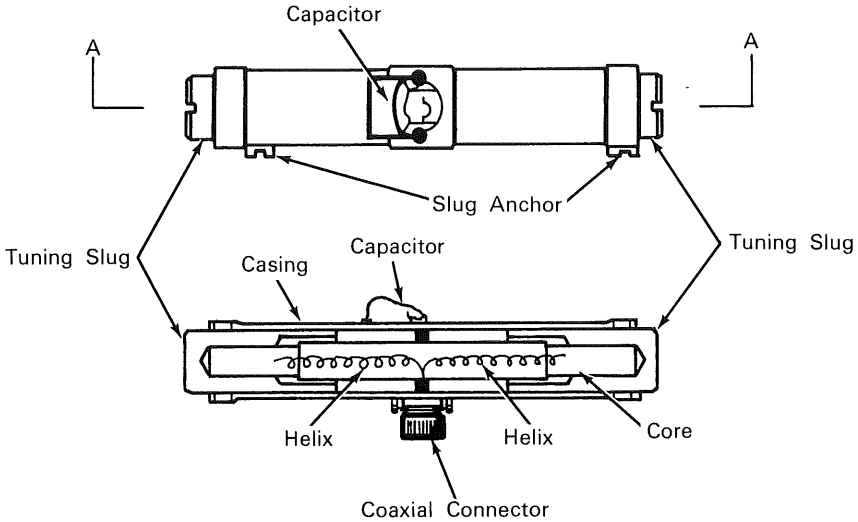
**Patent status:** NASA encourages the immediate commercial use of this invention. Inquiries about obtaining rights for its commercial use may be made to NASA, Code AGP, Washington, D.C., 20546.

Source: Justin C. Schaffert and
Norman E. Goldman
(GSFC-34A)

January 1965 Brief 65-10012

# NASA TECH BRIEF

## Helical Coaxial-Resonator Makes Excellent RF Filter



**The problem:** In certain applications, one antenna serves a dual function as both receiving and transmitting antenna. Where the transmit and receive frequencies are closely spaced, isolation of each from the other becomes an acute problem if the transmitter power is above a certain level. Conventional filtering of the receiver input line results in an intolerable insertion loss.

**The solution:** A helical-wound coaxial center conductor inside a metal tubing outer conductor exhibits a high value of characteristic impedance at high magnification factor. Attenuation of 25 to 27 db at the transmitter frequency has been obtained with practically zero db insertion loss at the receiver frequency where the receiver frequency is within ±8.5% of the transmitter frequency.

**How it's done:** An outer conductor is formed by the casing, turned from 5/8-inch aluminum bar stock 3-1/2-inches long. An inner conductor form is fabricated from 1/2-inch plastic rod stock grooved for winding two helices, which begin at the center and wind each way to the open circuit ends. The inner conductor (core) form is supported at each end by a tuning slug also turned from plastic rod stock and threaded internally to screw snugly on the end of the form. This achieves a continuous fine-tuning adjustment as it varies the amount of dielectric surrounding the open end of the inner conductor. The outer surface of the tuning slug fits snugly against the inner wall of the outer conductor. When fine tuning has been accomplished, a small screw is tightly self-tapped into each slug and on through into the inner conductor form. This effectively anchors the tuning slugs to prevent slipping and resultant detuning by environmental vibration. The center portion of the form is supported by flowing a resilient plastic around the center area, filling it completely to the inner wall of the casing and

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extending 1/16-inch either side of the center conductor lead where it extends outward to the coaxial connector.

**Note:** Inquiries concerning this invention may be directed to:

Technology Utilization Officer
Goddard Space Flight Center
Greenbelt, Maryland, 20771
Reference: B65-10012

**Patent status:** NASA encourages the immediate commercial use of this invention. Inquiries about obtaining rights for its commercial use may be made to NASA, Code AGP, Washington, D.C., 20546.

Source: Radio Corporation of America under
contract to Goddard Space Flight Center
(GSFC-243)

January 1965 Brief 65-10013

NASA TECH BRIEF

# Zener Diode Function Generator Requires No External Reference Voltage

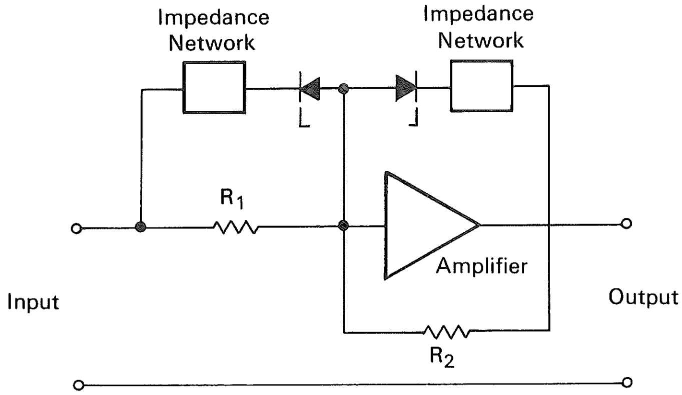

FIGURE 1

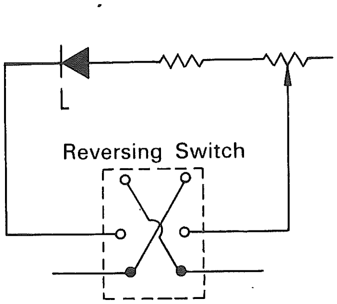

FIGURE 2

**The problem:** For many applications, an electronic differential analyzer requires a function generator that can produce functions discontinuous in slope as well as smooth monotonic and polytonic continuous functions. Diode function generators previously used alone or with smoothing oscillators require external voltage references and are subject to drift due to reference voltage drift as well as to temperature variations in the diodes.

**The solution:** A function generator using zener diodes is reasonably stable with temperature variations and requires no external reference voltage. The generator provides a wide variety of breakpoints and features repeatable operation with a minimum of recalibration required.

**How it's done:** The general layout of the zener diode function generator is shown in figure 1. An input signal is fed into $R_1$ which is connected in parallel with an impedance network and a zener diode. In series with these circuit elements is another parallel network consisting of a zener diode, a second impedance network, a high-gain dc amplifier, and a resistance $R_2$. The function generated appears at the output of this parallel network in the form of a voltage varying in time. The nature of this function depends on the two impedance networks. The network may consist of one or more basic cells of the type shown in figure 2, connected in parallel. The basic cell has a reversing switch for effecting an interchange of the external connections, a zener diode, a resistor, and potentiometer, all connected in parallel. The diode is selected for its zener voltage which determines the point in the generated function at which there is an abrupt change in the slope. This voltage is the point at which the resistance in the back direction is very low. Diodes are commercially available covering a wide range of zener voltage so that a great variety of functions may be generated with the proper selection of diodes.

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**Note:** Inquiries concerning this invention may be directed to:

Technology Utilization Officer
Jet Propulsion Laboratory
4800 Oak Grove Drive
Pasadena, California, 91103
Reference: B65-10013

**Patent status:** NASA encourages the immediate commercial use of this invention. Inquiries about obtaining rights for its commercial use may be made to NASA, Code AGP, Washington, D.C., 20546.

Source: George Bolte and
Robert Burns
(JPL-0031)

January 1965 Brief 65-10023

# NASA TECH BRIEF

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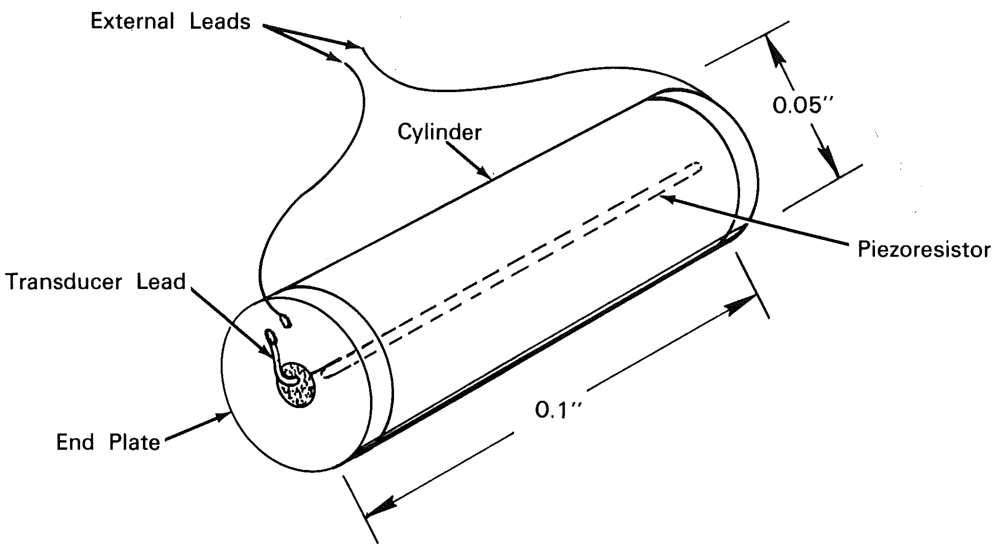
## Miniature Stress Transducer Has Directional Capability



**The problem:** The measurement of stresses internal to a mass and, especially, along the direction in which they are oriented.

**The solution:** A miniature stress transducer that employs a semiconductive piezoresistive element that is stress sensitive along a specific axis only.

**How it's done:** A semiconductive transducer is fashioned from a p-type silicon splinter embedded in a centerless ground, high-density, polyethylene cylinder. The silicon splinter is a piezoresistor grown in a selected crystallographic orientation to possess piezoresistive characteristics along a selected axis. Brass end plates, drilled for the transducer leads, are fastened to the transducer cylinder ends using an epoxy adhesive. The assembly is held in a fixture while epoxy adhesive is injected into the cylinder to embed the silicon splinter permanently. The transducer leads are resistance welded to the brass end plates that include external leads for connection to instrumentation.

The mechanism of measurement is based on the compressive deformation of the transducer. Loading of the transducer cylinder along the piezoresistor's sensitive axis changes resistance of the silicon splinter in direct relation to the amount of stress applied. Various deformation sensitivities are possible by using cylinders of differing Young's modulus.

**Notes:**

1. Other cylinder materials which exhibit the characteristics of homogeneous structure, low modulus, nonconductivity, ease of machining, and good bonding to the semiconductor crystal have been found to be suitable, e.g., etched teflon.

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2. Materials having poor bonding qualities, e.g., nylon, were found to be unsatisfactory.
3. A number of transducers may be readily mounted about a point region in a structural member, each aligned with a direction of interest, thereby obtaining multiaxial stress analysis of the point region.
4. This transducer would be useful for constant monitoring of stress in structural members of buildings, dams, etc.
5. Inquiries concerning this invention may be directed to:

Technology Utilization Officer
Jet Propulsion Laboratory
4800 Oak Grove Drive
Pasadena, California, 91103
Reference: B65-10023

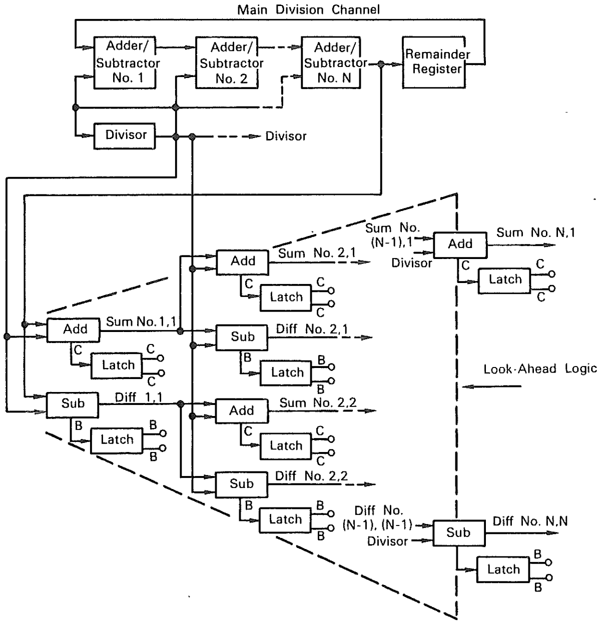
**Patent status:** NASA encourages the immediate commercial use of this invention. Inquiries about obtaining rights for its commercial use may be made to NASA, Code AGP, Washington, D.C., 20546.

Source: Anthony San Miguel and
Robert H. Silver
(JPL-591)

February 1965 Brief 65-10005

# NASA TECH BRIEF

## Computer Modification Reduces Time of Performing Iterative Division


Main Division Channel
Adder/ Subtractor No. 1
Adder/ Subtractor No. 2
Adder/ Subtractor No. N
Remainder Register
Divisor
Divisor
Sum No. (N-1),1
Divisor
Add
Sum No. N,1
Latch
C
Add
Sum No. 2,1
Latch
C
Add
Sum No. 1,1
Latch
Sub
Diff No. 2,1
Latch
B
Look-Ahead Logic
Sub
Diff 1,1
Latch
B
Add
Sum No. 2,2
Latch
Sub
Diff No. 2,2
Latch
Diff No. (N-1), (N-1)
Divisor
Sub
Diff No. N,N
Latch

**The problem:** Reducing the time required to perform iterative division. The division process is one of the most complex and time-consuming internal operations of a computer. In iterative division, successive additions or subtractions are performed between the divisor and dividend remainder, depending upon the sign relationship between the preceding remainder and divisor. Conventionally, this process requires one computer cycle per quotient bit because the sign of the remainder is the last item to be determined from the preceding iteration.

**The solution:** A serial-by-parallel divider employing a look-ahead feature that predetermines the sign relationships of several iterations before the computer cycle begins. Thus, several add/subtract decisions can be made and implemented in one computer cycle.

**How it's done:** The block diagram presents a serial-by-parallel divider with an N-iteration look-ahead logic configuration. Timing-signal lines, the quotient register, and the command control lines between the look-ahead logic section and the adder/subtractors are omitted for simplicity. The look-ahead logic section is a branching configuration of adders and subtractors. The divisor and the dividend remainder information bits pass through all the adders and subtractors with no delay or interim storage other than the inherent delay encountered in circuit components. Only the carry (C) and the borrow (B) conditions of the most significant bit are retained in latches at each branching level. These carry and borrow conditions at each level uniquely describe the sign relation between the divisor and the remainder

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for the associated iteration and are employed to preset the appropriate adder/subtractor in the main division channel.

**Notes:**

1. Any number of iterative divisions can be made in only one computer cycle using this method. However, the number of components required would be prohibitive for more than a three- or four-iteration look-ahead, because the branching increases geometrically for each decision level that is introduced.
2. This method can be employed in any data handling system in which high-speed division must be performed in a serial arithmetic unit.
3. Inquiries concerning this innovation may be directed to:

   Technology Utilization Officer
   Marshall Space Flight Center
   Huntsville, Alabama, 35812
   Reference: B65-10005

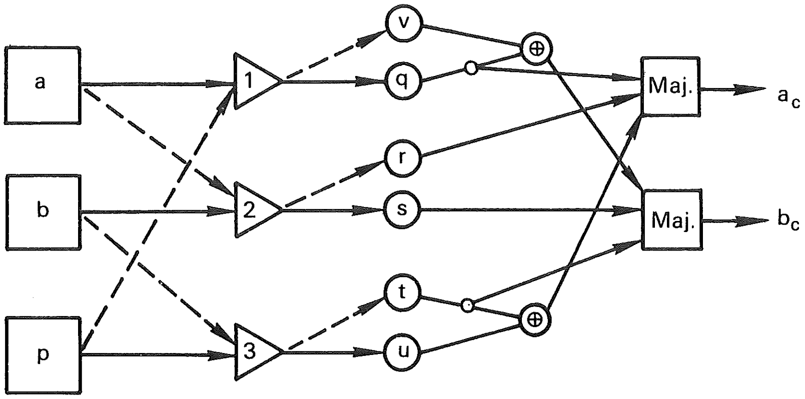
**Patent status:** NASA encourages commercial use of this innovation. No patent action is contemplated.

Source: International Business Machines Corp.
under contract to Marshall Space Flight Center
(M-FS-166)

February 1965 Brief 65-10025

# NASA TECH BRIEF

## Logic Redundancy Improves Digital System Reliability



**The problem:** In binary-signal systems, the generation of false zeros and false ones due to noise or faulty equipment are not uncommon. These false signals result in errors in communication or computation and repetition of message is not always feasible.

**The solution:** A redundant-channel system that automatically corrects any single error in a set of three binary signal channels.

**How it's done:** The system is composed of four parts as shown in the illustration:

(1) Simultaneous binary signal sources $a$, $b$, and $p$.
(2) Signal channels 1, 2, and 3.
(3) Temporary storage elements $q$, $r$, $s$, $t$, $u$, and $v$.
(4) Logic circuits consisting of parity functions ($\oplus$) and majority functions.

Signal sources $a$ and $b$ are independent but source $p$ produces a signal that is the parity function of $a$ and $b$, that is, it is 1 if $a$ and $b$ are unlike, and 0 if $a$ and $b$ are like values. In a computer, if $a$ and $b$ are logical functions of a set of variables, $x$, $p$ may be derived directly as a combinational function of $a$ and $b$, or indirectly from the same set of variables, $x$. In this system, identical values of $a$, $b$, and $p$ are produced twice. The first set of values $a$, $b$, and $p$ are transmitted through channels 1, 2, and 3, respectively, and stored in elements $q$, $s$, and $u$, these transmissions being represented by the heavy solid lines in the figure. The second set of values of $a$, $b$, and $p$ are transmitted (along the dotted lines) through channels 2, 3, and 1, respectively, that is, transposed with respect to the first transmission, and stored in elements $r$, $t$, and $v$. The signals $a_c$ and $b_c$ are generated by the combinational logic elements as the following functions:

$$a_c = \text{majority function } (q, r, [t \oplus u])$$
$$b_c = \text{majority function } (s, t, [q \oplus v])$$

where the majority function of three binary variables is defined as being 1 if, and only if, two or three of the variables are 1, and the symbol $\oplus$ represents the parity function of the associated variables as defined above. The functions $a_c$ and $b_c$ are the true values of the independent signals $a$ and $b$, respectively, if there is no more than one faulty channel. The explanation of

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this for $a_c$ is that: if channels 1, 2, and 3 are perfect then $q$, $r$, and $v$ have the value $a$ and $[t \oplus u]$ also has the value $a$, since $t = b$, $u = p$ $[a \oplus b]$, and $(b \oplus (a \oplus b)) = a$. Finally, the majority function of $(a, a, a)$ is $a$. If one of the channels fails, only one of the values $q$, $r$, or $[t \oplus u]$ may differ from the others, so that the majority function of the three still has the value $a$. The explanation for $b_c$ follows a similar argument.

## Notes:

1. This system could be used to correct signal channel errors in applications where data is transmitted naturally in parallel channels, such as within a digital computer, and where the channel is substantially less reliable than the associated correction equipment.
2. Inquiries concerning this invention may be directed to:

   Technology Utilization Officer
   Jet Propulsion Laboratory
   4800 Oak Grove Drive
   Pasadena, California, 91103
   Reference: B65-10025

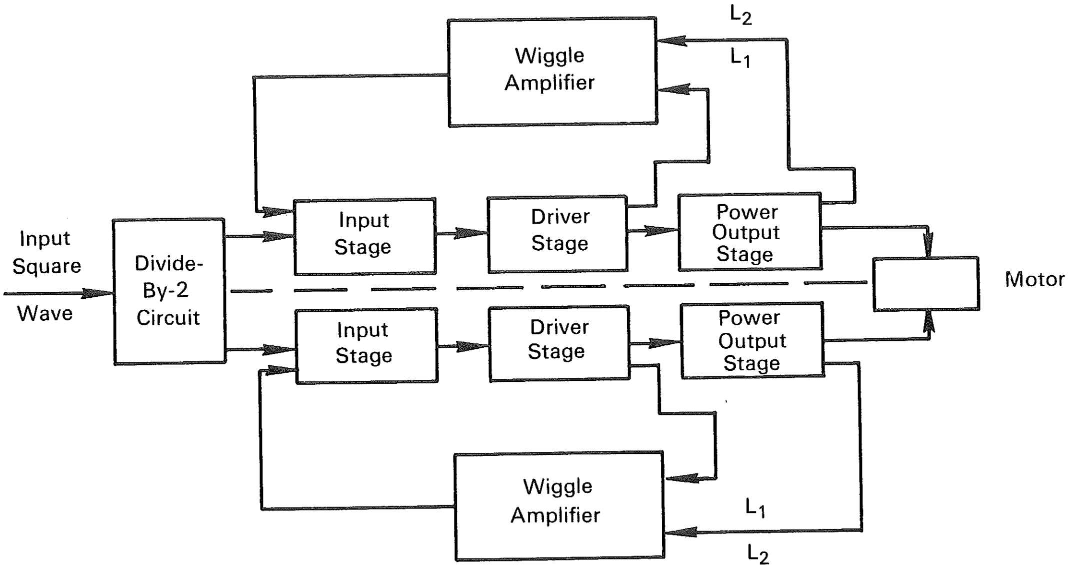
**Patent status:** NASA encourages the immediate commercial use of this invention. Inquiries about obtaining rights for its commercial use may be made to NASA, Code AGP, Washington, D.C., 20546.

Source: Stanford Research Institute
under contract to Jet Propulsion Laboratory
(JPL-SC-069)

February 1965 Brief 65-10026

# NASA TECH BRIEF

## Stepping Motor Drive Circuit Designed for Low Power Drain



**The problem:** To eliminate high power drain and variations in mechanical load, temperature, and supply voltage from a stepping motor drive circuit system.

**The solution:** A stepping motor drive circuit design, incorporating a switch with less than 1-volt drop when conducting, and minimal leakage of microamperes when nonconducting. Each drive pulse causes a step, with power drain close to zero when the motor is stopped in an equilibrium position.

**How it's done:** The circuit consists of a divide-by-two stage, and two identical input, wiggle amplifier, driver, and power output stages to drive the motor through a brief operating cycle.

The divide-by-two applies square waves (180° out-of-phase) to the input stages. With $L_1$ connected, the input, driver, and wiggle amplifier form a one-shot multivibrator. When the waveform at the input goes from positive to negative, this multivibrator locks on and the power output stage conducts. An RC network discharge in the input causes conduction in that stage, and the multivibrator becomes regenerative in the opposite direction. The circuit then reverts to its original state, and the power output stage turns off.

This procedure is repeated when $L_2$ is connected, but turnoff is not determined by the RC network. When the motor steps, a wiggle is generated in the power output stage, amplified in the wiggle amplifier, and fed back to the input stage as a positive pulse. The input stage then turns on, the multivibrator becomes passive, and the power stage turns off.

If the motor freezes, no wiggle appears, and the RC network turns off the circuit.

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**Notes:**

1. Adaptations of this switching device may be of interest in relay circuitry design.
2. Step motors are suitable as rotary actuators in a variety of small positioning control systems, particularly where the overall system is digital.
3. Inquiries concerning this invention may be directed to:

   Technology Utilization Officer
   Goddard Space Flight Center
   Greenbelt, Maryland, 20771
   Reference: B65-10026

**Patent status:** NASA encourages the immediate commercial use of this invention. Inquiries about obtaining rights for its commercial use may be made to NASA, Code AGP, Washington, D.C., 20546.

Source: Harvard College
under contract to Goddard Space Flight Center
(GSFC-198)

February 1965

Brief 65-10028

# NASA TECH BRIEF

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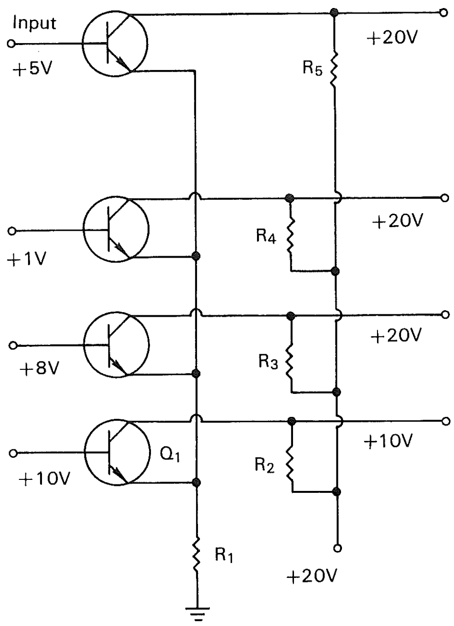
## Transistor Voltage Comparator Performs Own Sensing



**The problem:** Detection of the highest voltage input among a group of varying voltage inputs. The sensing circuit must function without the aid of external circuits.

**The solution:** A transistorized circuit that can be directly coupled to a binary encoder for readout.

**How it's done:** The voltage comparison circuit uses one transistor for each input line being monitored. The base-emitter junctions of the transistors are connected as in a standard diode comparator circuit. The collector circuits of the transistors perform the sensing function.

The emitters of all the transistors are tied to one common resistor $R_1$. Each transistor has a load resistor in its collector circuit. With the maximum input voltage on the base of $Q_1$, the base-emitter junction of $Q_1$ will be the only one forward biased. Transistor $Q_1$ will be conducting and the voltage at the emitters of all transistors will be equal to the voltage on the base of $Q_1$ minus the voltage drop across the base-emitter junction of $Q_1$. Voltages on the emitters of all transistors except $Q_1$ will be more positive than the voltages on their respective bases and they will be cut off. The output voltages of these transistors will be very high compared to that of $Q_1$.

**Notes:**

1. Although NPN transistors are shown, PNP may be used with reversed polarities.
2. This circuit could be used to advantage wherever diode comparator gates are presently in use.

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3. Input voltage levels will be governed by the transistors used.
4. The individual values of $R_2$, $R_3$, $R_4$, and $R_5$ are much greater than $R_1$.
5. Inquiries concerning this invention may be directed to:

   Technology Utilization Officer
   Goddard Space Flight Center
   Greenbelt, Maryland, 20771
   Reference: B65-10028

**Patent status:** NASA encourages the immediate commercial use of this invention. Inquiries about obtaining rights for its commercial use may be made to NASA, Code AGP, Washington, D.C., 20546.

Source: Rodger A. Cliff
(GSFC-228)

February 1965

Brief 65-10030

# NASA TECH BRIEF

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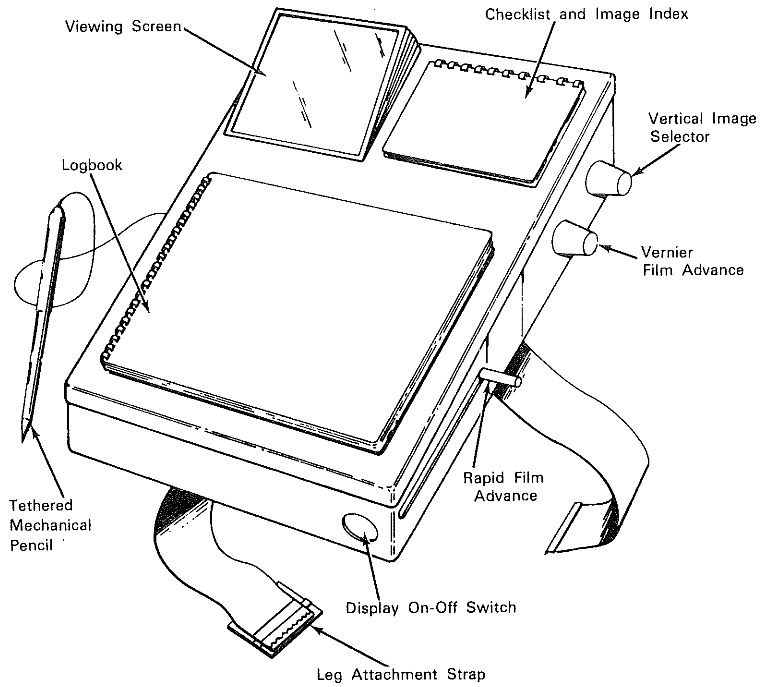
## Library of Documents Compressed into Lap-Held Display Kit



**The problem:** The manuals, maps, star charts, emergency plans, etc. required in duplicate for the crew of the Apollo mission amount to 12,000 printed pages with a total weight of 79 pounds per kit. This involves a total weight of 158 pounds and a bulk of material, both unacceptable considering mission objectives.

**The solution:** A package using microfilm in conjunction with a viewing screen to present the 12,000 printed pages rapidly. The package weighs three pounds and is about the size of a metropolitan telephone directory.

**How it's done:** A package, called a Flight Kit Assembly, was designed to contain and provide readout of some 12,000 pages of information related to the navigation, operation, and maintenance of the Apollo flight spacecraft. The assembly consists of a locking case with a hinged cover that serves as a lap-held writing surface. The cover includes a 4- by 5-inch viewing screen in the upper left corner. The 12,000 pages of data are on microfilm that is moved by external manual controls. Using a checklist and image index mounted on the upper right corner of the cover, the user can view any page selected in a maximum of

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15 seconds. A logbook and mechanical pencil attached to the lower portion of the cover provides a means of recording observed phenomena during flight. A manual switch is used to display selected data on the viewing screen. An elastic strap attached to the bottom of the case holds the assembly firmly in place on the user's lap.

## Notes:

1. This kit could be adapted for use by survey crews requiring large numbers of maps or on construction projects involving numerous blueprints.
2. Inquiries concerning this innovation may be directed to:

   Technology Utilization Officer
   Manned Spacecraft Center
   P.O. Box 1537
   Houston, Texas, 77001
   Reference: B65-10030

**Patent status:** NASA encourages commercial use of this innovation. No patent action is contemplated.

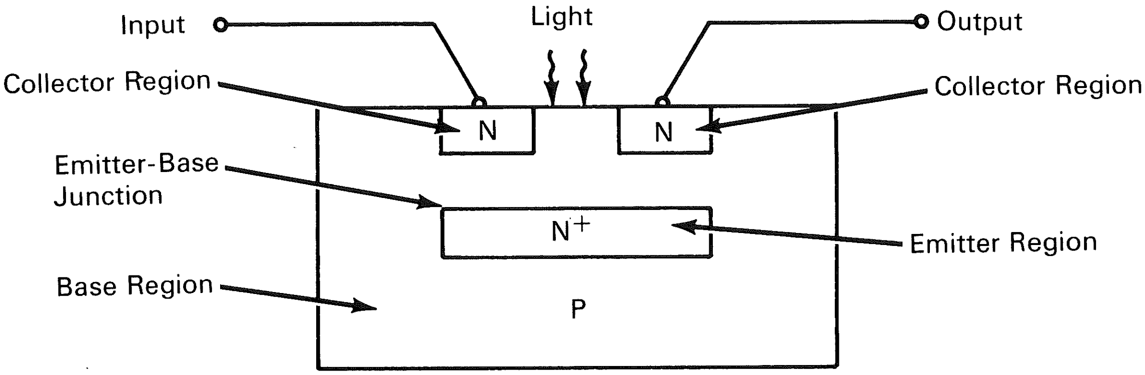
Source: National Cash Register Co., under subcontract to Manned Spacecraft Center
(MSC-125)

February 1965

Brief 65-10033

# NASA TECH BRIEF

## Photoelectric Semiconductor Switch Operates with Low Level Inputs



**The problem:** It is frequently desirable to have a photoelectric switch operate at very low input levels while providing adequate gain. Previous devices have exhibited high-leakage current across the emitter-base junction which causes poor operation at low input levels.

**The solution:** A photoelectric semiconductor switch that exhibits high emitter-to-collector transport efficiency beta at low signal levels.

**How it's done:** An $N^+$-type emitter region is buried in a P-type wafer that serves as the base region of the switch. Properly spaced N-type collector regions are diffused into the surface of the base region above the emitter region and are electrically connected as input and output for the device being controlled.

Light reaching the upper surface of the switch passes through the base region and strikes the buried emitter region. Minority carriers are then released by the emitter region and travel through the intervening portion of the base region to the collector regions thus establishing a low-impedance path between the input and output connections. Because the emitter region is buried, high-leakage currents across the emitter-base junction are avoided and it functions more like an ideal emitter than one which operates at the surface of the device. The emitter-base junction being inherently passivated results in emitter-to-collector transport efficiency beta higher than that of prior photoelectric semiconductor switches, especially at low signal levels.

**Notes:**

1. This device could find broad application in the automotive, alarm, instrumentation, and process control industries.
2. The switch could be used to switch city street lights on and off as daylight passed preselected thresholds.
3. Inquiries concerning this innovation may be directed to:

Technology Utilization Officer
Jet Propulsion Laboratory
4800 Oak Grove Drive
Pasadena, California, 91103
Reference: B65-10033

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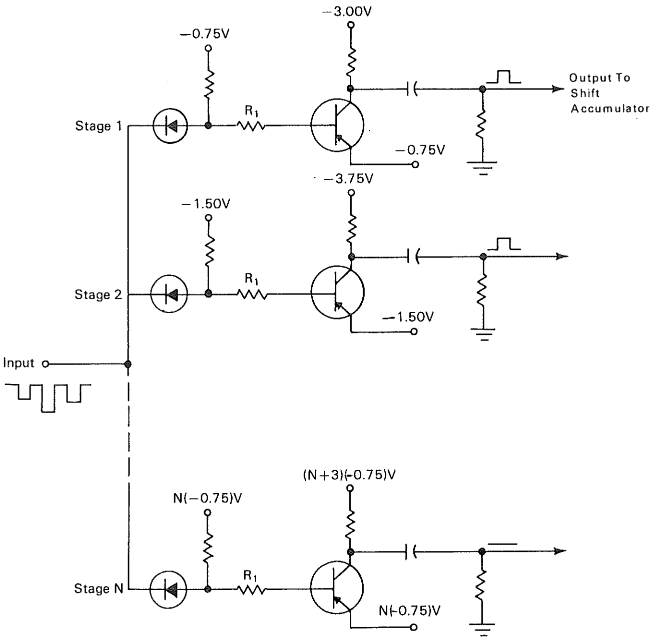
**Patent status:** NASA encourages commercial use of this innovation. No patent action is contemplated.

Source: International Business Machines under contract to Jet Propulsion Laboratory (JPL-SC-068)

February 1965 Brief 65-10041

# NASA TECH BRIEF

## Pulse Height Analyzer Operates at High Repetition Rates, Low Power



**The problem:** Providing a pulse height analyzer that operates at pulse repetition rates as high as 10 to 20 megacycles per second. Conventional pulse height analyzers employing digital feedback circuitry cannot be driven at such high pulse rates and waste power when no input pulses are applied.

**The solution:** A simple multistage transistor gating circuit that compares the input pulse heights (voltages) to discrete reference voltages. The number of stages required for this circuit is determined by the range of pulse heights to be measured, and only seven components are needed for each stage.

**How it's done:** Each pulse in a train of negative pulses is admitted simultaneously to the base of the transistor in each of the stages (1 to N). The transistors (base and emitter of each transistor) are biased by a reference voltage so that they produce an output voltage for any pulse height less (i.e., greater in absolute value) than the particular reference level. The reference levels are established in decreasing equal increments. As shown in the circuit diagram, the reference bias voltage for the first stage is −0.75 volt; for the second stage, −1.50 volts; and for the Nth stage, N(−0.75) volts. The voltage references may be chosen so that the circuit measures any desired voltage difference, the minimum difference being determined by the transistor used.

When no input pulse is applied, all the transistors are turned off, because each transistor is biased to the

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same extent (voltage on base equals voltage on emitter) by the regulated power supplies V1, V2, . . . . VN. The diodes block interaction between stages, and thus prevent one stage from turning on another stage. When a negative pulse on the input terminal is less than −0.75 volt, for example, the first-stage transistor begins to conduct and an output voltage pulse appears at its collector. This pulse is then stored in the shift accumulator. As the input voltage continues to decrease to lower bias levels, succeeding stages (i.e., stage 2, 3, etc.) turn on, and their outputs are stored in the shift accumulator. The height of each pulse is read from the accumulator position that corresponds to the highest stage for that pulse.

**Notes:**

1. The collector voltage supplies need not be closely regulated.
2. For operation at low frequencies (less than 300 kc per sec) a single voltage supply with a resistive divider may be satisfactory for the base and emitter bias voltages. At higher frequencies, however, a separate regulated supply will be needed for each of these voltages.
3. The operating speed of the analyzer can be increased by shunting each resistor $R_1$ with a capacitor.
4. Inquiries concerning this innovation may be directed to:

   Technology Utilization Officer
   Western Operations Office
   150 Pico Boulevard
   Santa Monica, California, 90406
   Reference: B65-10041

**Patent status:** NASA encourages commercial use of this innovation. No patent action is contemplated.

Source: Space Technology Laboratories, Inc.
under contract to Western Operations Office
(WOO-046)

February 1965

Brief 65-10045

# NASA TECH BRIEF

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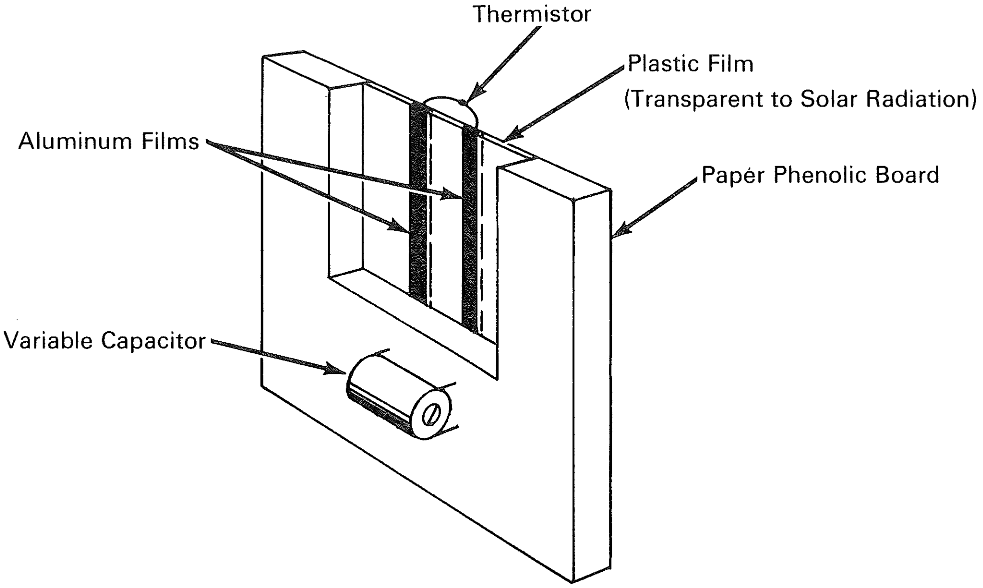
## Thermistor Connector Assembly Increases Accuracy of Measurements



**The problem:** Accurately measuring ambient air temperatures with a thermistor which is subject to spurious heat transfer by conduction through its mounting and electrical leads. The thermistor is to be rigidly mounted as a probe to be used in conjunction with high-frequency radio instrumentation which will telemeter high-altitude air temperatures from a meteorological sounding system. Under these operating conditions, sources of heat transfer which can introduce errors into the temperature measurements arise from ohmic heating in the instrumentation package, radio frequency heating, and solar radiation. In order to minimize these errors, the thermistor mounting and connectors must have a low thermal mass and large area, so that they can rapidly come to equilibrium with the ambient air; they must be highly reflective or transparent to solar radiation; and they must be protected against absorption of the high-frequency radio waves transmitted by the telemetering system. The thermistor leads must be very short, as they are poor reflectors of solar radiation.

**The solution:** A mounting which effectively isolates the thermistor from spurious heat transfer due to ohmic heating, solar radiation, and absorption of high-frequency radio energy. The thermistor is connected to the mounting by means of very short leads.

**How it's done:** A 1-mil-thick film of transparent plastic is firmly bonded to a 1/16-inch-thick U-shaped paper phenolic board. This assembly is suitably masked and two films of aluminum are vacuum deposited on each face of the plastic film. Aluminum is also

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deposited on the upper edge of the plastic film, so that the aluminum films form a pair of inverted U-shapes (as viewed from the edge of the plastic film). The leads of the thermistor are soldered to the aluminum films at the U-bends. The aluminum films are approximately 15,000 Angstroms thick and 2 millimeters wide and are separated by approximately 3 millimeters. The length of each leg of aluminum film is made equal to one-quarter of the wavelength of the radio energy to be transmitted. These legs thus form a resonant transmission line which is capable of short-circuiting the radio energy appearing across them and thereby prevent its conversion to heat. In addition to serving as a short-circuiting means, the aluminum film has a high reflectance for solar radiation and therefore gains little heat from this source. A variable capacitor is mounted on the phenolic board and is electrically connected to the bottom ends of the aluminum films. This capacitor is used for fine-tuning the aluminum-film transmission line to one-quarter the wavelength of the radio energy. Connections to an external dc measuring circuit (which is part of the telemetering system) are soldered to the ends of the film strips near the capacitor.

**Notes:**

1. Tests on the thermistor mounting assembly indicate that the need for tuning is not critical; it should therefore be practical to replace the variable capacitor with one of fixed value.
2. This assembly should be useful for accurately measuring the temperature of air or other gases in environments where thermal radiation and radio frequency heating may cause problems.
3. Inquiries concerning this innovation may be directed to:

Technology Utilization Officer
Langley Research Center
Langley Station
Hampton, Virginia, 23365
Reference: B65-10045

**Patent status:** NASA encourages commercial use of this innovation. No patent action is contemplated.

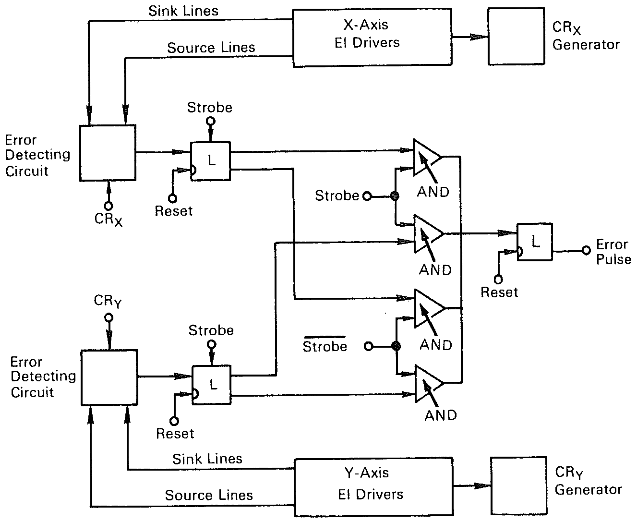
Source: Atlantic Research Corporation under
contract to Langley Research Center
(Langley-62)

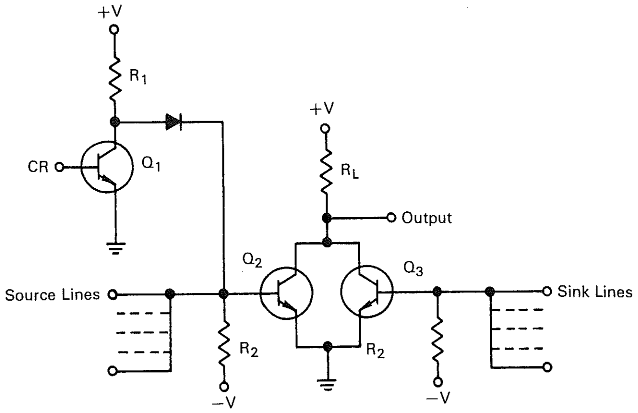
February 1965

Brief 65-10047

# NASA TECH BRIEF

## Circuit Detects Errors in Address Currents for Magnetic Core Arrays


Sink Lines
Source Lines
X-Axis
EI Drivers
$\text{CR}_X$
Generator
Strobe
Error
Detecting
Circuit
L
$\text{CR}_X$
Reset
Strobe
AND
AND
L
Error
Pulse
Reset
$\text{CR}_Y$
Strobe
$\overline{\text{Strobe}}$
AND
AND
Error
Detecting
Circuit
L
Reset
Sink Lines
Source Lines
Y-Axis
EI Drivers
$\text{CR}_Y$
Generator


+V
$R_1$
CR
$Q_1$
+V
$R_L$
Output
$Q_2$
$Q_3$
Source Lines
Sink Lines
$R_2$
$R_2$
–V
–V

**The problem:** Error detection in voltage source (E)-current sink (I) half-select addressing of magnetic core memory arrays. In such a system each EI pair drives a discrete half-select line in the memory. All combinations of EI pairs are employed. Thus half-select addressing is accomplished by discretely actuating one voltage source circuit and one current source circuit. Any of the following conditions can introduce output errors in this system: address without voltage source, without current sink, or without voltage source-current sink; address with multiple sources and single sink, with single source and multiple sinks, or with multiple sources and sinks; or address out-of-time (transient addressing).

**The solution:** An address current error detector that generates a signal whenever any of the error-producing conditions arise.

**How it's done:** As indicated in the block diagram of the system, an error detecting circuit is provided for each addressing coordinate. The outputs of all the voltage sources and current sinks plus the coordinate address clock (CR, i.e., $\text{CR}_x$ or $\text{CR}_y$) pulse are monitored by the associated error detecting circuit. If one source and one sink circuit are actuated when the current address clock pulse is present, no signal is generated by the error detecting circuit. However, if any other combination of sources, sinks, and the coordinate address clock pulse (present or absent) is impressed upon the error detecting circuit, it generates a signal that is processed by latch circuits and AND gates to present an error pulse at the output of the error detection system.

Details of the error detecting block are shown in the circuit diagram. In the absence of a CR pulse and any

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source or sink signal, transistor $Q_2$ is saturated; as a result, the bias current through $R_1$ and the output level are down. When only a CR pulse is present, $Q_2$ turns off, and the output level is up. In this case, a single source signal and a single sink signal will not override the back bias through the resistors $R_2$, and the output remains up. If two or more source signals are present, $Q_2$ turns on and the output level is down. If two or more sink signals are present, $Q_3$ turns on, and the output level is down. The CR pulse is not generated unless one source signal and one sink signal are present. Thus, during the time of a strobe signal at the AND gates, an up level on the output indicates error-free operation and a down level indicates erroneous operation.

**Notes:**

1. The error detection system is compatible with most memory configurations employing source-sink addressing or driver-gate addressing. It may also have application in test equipment to determine signal coincidence.
2. Inquiries concerning this innovation may be directed to:

   Technology Utilization Officer
   Marshall Space Flight Center
   Huntsville, Alabama, 35812
   Reference: B65-10047

**Patent status:** NASA encourages commercial use of this innovation. No patent action is contemplated.

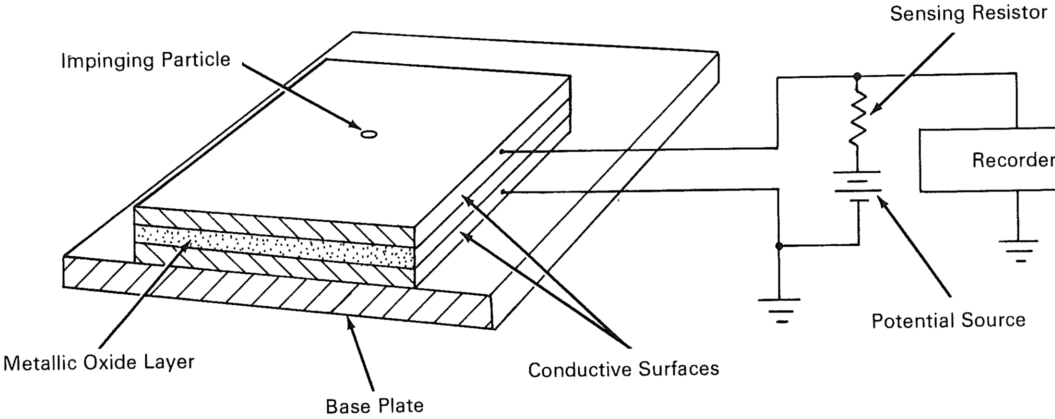
Source: International Business Machines Corporation,
under contract to Marshall Space Flight Center
(M-FS-234)

February 1965

Brief 65-10048

# NASA TECH BRIEF

## Microparticle Impact Sensor Measures Energy Directly



**The problem:** Small particles such as micrometeorites and steller and nebular dust form an important constituent of space. Information as to spatial density, mass, velocity, and direction of travel of these particles is necessary for future space exploration. Previous sensors have suffered from either or both of two limitations: gradual degradation of sensitivity by particle penetration, or a sensitivity threshold that prevents a measurable response to particle impact below a certain energy level.

**The solution:** A plate capacitor-type sensor whose response is a direct measurement of the relative energy of the impinging particle. Particles of sufficient energy to penetrate the sensor have no degrading effect.

**How it's done:** A thin film of conductive material is deposited on a glass base plate. A thin layer of nonconducting metallic oxide (silicon or aluminum) is deposited on the conductive film and a layer of conductive material is deposited on the metallic oxide layer. This forms a capacitor with the conductive layers acting as the plates and the metallic oxide as the dielectric. The upper conductive layer forms the target area. The two conductive layers are connected across a potential source through a sensing resistor. An impinging particle introduces a shock wave that is propagated through the metallic oxide layer. This produces localized heating that momentarily lowers the impedance of the metallic oxide layer in proportion to the intensity of the shock wave. This results in a discharge of the capacitor producing a signal across the sensing resistor of an amplitude which is a function of total particle energy. The intense heating of the metallic oxide layer does not materially alter its chemical composition and it returns immediately to its normally high-impedance state.

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**Notes:**

1. It is not necessary that the dielectric layer be penetrated to produce a measurable response. Particles that do penetrate the dielectric layer do not leave a charred, conductive path.
2. Inquiries concerning this invention may be directed to:

   Technology Utilization Officer
   Goddard Space Flight Center
   Greenbelt, Maryland, 20771
   Reference: B65-10048

**Patent status:** NASA encourages the immediate commercial use of this invention. Inquiries about obtaining rights for its commercial use may be made to NASA, Code AGP, Washington, D.C., 20546.

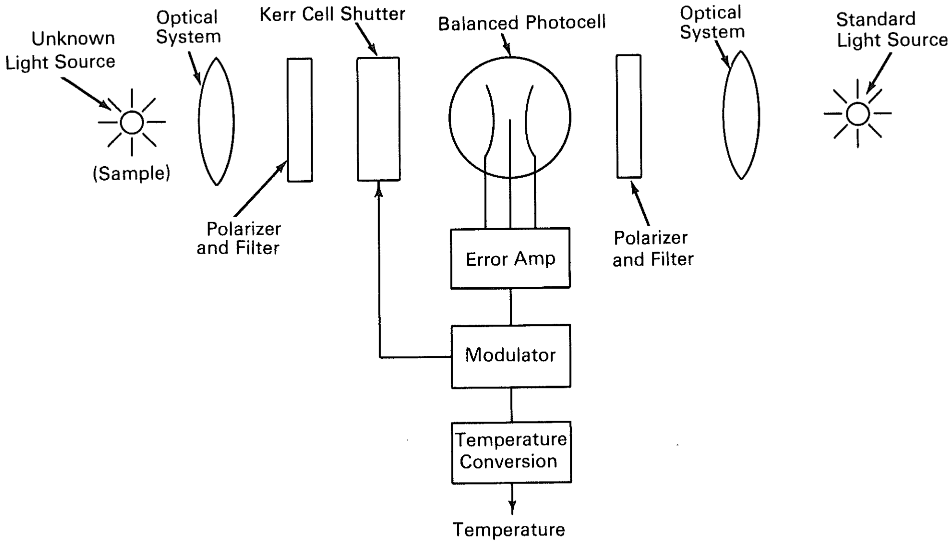
Source: Otto E. Berg and W. Merle Alexander
(GSFC-252)

February 1965

Brief 65-10050

# NASA TECH BRIEF

## Nulling Pyrometer Uses Kerr Cell Shutter for Fast Response



**The problem:** For measuring very rapid temperature changes in a sample, conventional pyrometers using mechanical shutters do not respond rapidly enough.

**The solution:** A pyrometer system that uses a Kerr cell in place of a mechanical shutter plus the addition of polarizers to the filters.

**How it's done:** A commercially available photocell consisting of a matched pair of elements in a single envelope forms the sensing element in the system. The output of the two elements is fed to an error amplifier which generates a signal proportional to the difference in intensity between the sample and the standard source. This error signal is used to modulate the Kerr cell shutter to adjust the amount of light reaching the photocell from the sample. The amount of modulation required to match the sample and the standard is proportional to the temperature of the sample and a conversion stage supplies a direct temperature readout.

**Notes:**

1. This system is capable of very rapid response as the Kerr cell is operable as a shutter up to $10^9$ cycles per second.
2. Inquiries concerning this innovation may be directed to:

   NASA Space Nuclear Propulsion Office
   Technology Utilization Branch
   U.S. Atomic Energy Commission Bldg.
   Germantown, Maryland
   Reference: B65-10050

**Patent status:** NASA encourages commercial use of this innovation. No patent action is contemplated.

Source: Westinghouse Electric Corporation
under contract to NASA Space Nuclear
Propulsion Office (NU-0010)
Category No. 01

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February 1965

Brief 65-10051

# NASA TECH BRIEF

## Metal Sheath Improves Thermocouple Using Graphite in One Leg

**The problem:** Design of a thermocouple with high EMF output and good reproducibility that is rugged and moistureproof. Combinations including graphite have exhibited more than 10 times the EMF output of other available thermocouples but have proven fragile and subject to change in EMF due to absorption of moisture and contaminants.

**The solution:** Thermocouples using graphite in one leg are enclosed in a moistureproof metal sheath.

**How it's done:** After assembly the thermocouple is baked out to eliminate all moisture and then sealed in a metal sheath. Lead wires from the elements are brought out through moistureproof seals. The metal sheath gives the thermocouple mechanical strength.

**Notes:**

1. A graphite-silicon carbide combination has an EMF output of 0.5 volt at 3000° F while a graphite-boron carbide device has an output of 0.7 volt at 4530° F.
2. Inquiries concerning this innovation may be directed to:

NASA Space Nuclear Propulsion Office
Technology Utilization Branch
U.S. Atomic Energy Commission Bldg.
Germantown, Maryland
Reference: B65-10051

**Patent status:** NASA encourages commercial use of this innovation. No patent action is contemplated.

Source: Westinghouse Electric Corporation
under contract to NASA Space Nuclear
Propulsion Office (NU-0011)

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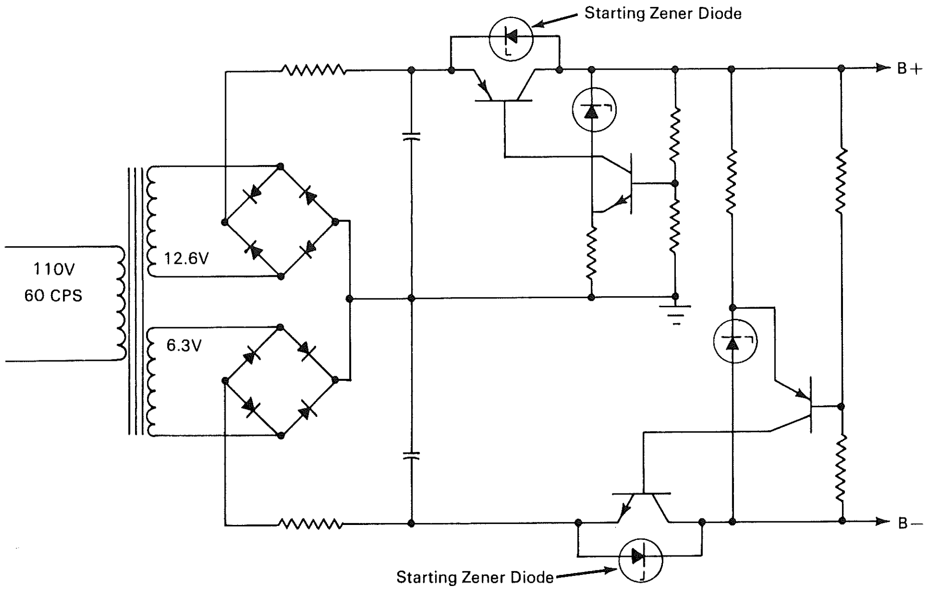
February 1965 Brief 65-10052

# NASA TECH BRIEF

## Zener Diode Is Starter for Transistor-Regulated Power Supply



**The problem:** Power supplies using high-quality silicon transistors as variable impedance regulators require an initial starting current supply because these silicon transistors have exceedingly small leakage current. Previous starting techniques have been very complex and expensive.

**The solution:** A zener diode in parallel with the silicon transistor supplies the starting current.

**How it's done:** A zener diode of suitable voltage is connected in parallel with the silicon transistor used as the variable impedance in each leg of the regulation portion of the circuit. The voltage developed across the diode provides an initial current through the transistor, sufficient to turn it on. The diodes are selected with zener voltage large enough to provide sufficient starting current but small enough to be effectively open-circuited with the transistor on.

**Note:** Inquiries concerning this innovation may be directed to:

NASA Space Nuclear Propulsion Office
Technology Utilization Branch
U.S. Atomic Energy Commission Bldg.
Germantown, Maryland
Reference: B65-10052

**Patent status:** NASA encourages commercial use of this innovation. No patent action is contemplated.

Source: Westinghouse Electric Corporation
under contract to NASA Space Nuclear
Propulsion Office (NU-0015)
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March 1965 Brief 65-10054

# NASA TECH BRIEF

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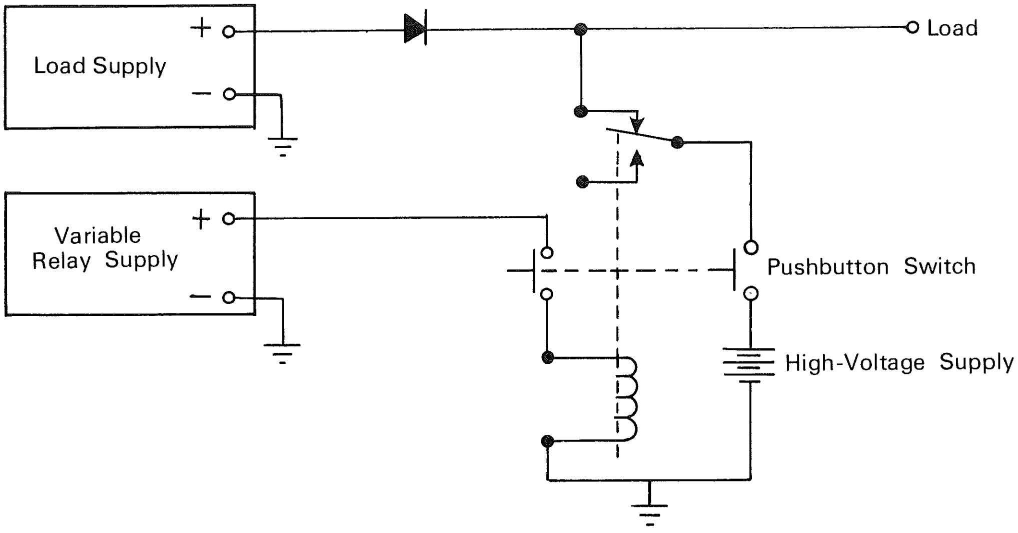
## Pulse Generator Permits Nondestructive Testing of Component Breakdown Voltage



**The problem:** Devising a nondestructive test for determining the breakdown voltage of transistors and other electronic components.

**The solution:** A simple relay circuit that permits application of low-energy, high-voltage microsecond pulses to the components under test.

**How it's done:** The high-voltage dc power supply is normally disconnected from the test component, represented as the load in the circuit diagram, by the two-section pushbutton. When the pushbutton is depressed, the high-voltage supply is connected to the load and power is simultaneously supplied to the relay coil from the variable supply. The voltage applied to the load is of microsecond duration, as it is determined only by the rise time required to energize the relay coil and open its normally closed contact. The diode blocks the high voltage from the load supply.

**Note:** Inquiries concerning this innovation may be directed to:

Technology Utilization Officer
Manned Spacecraft Center
P.O. Box 1537
Houston, Texas, 77001
Reference: B65-10054

**Patent status:** NASA encourages commercial use of this innovation. No patent action is contemplated.

Source: Honeywell, Inc. under contract to
Manned Spacecraft Center
(MSC-122)
Category No. 01

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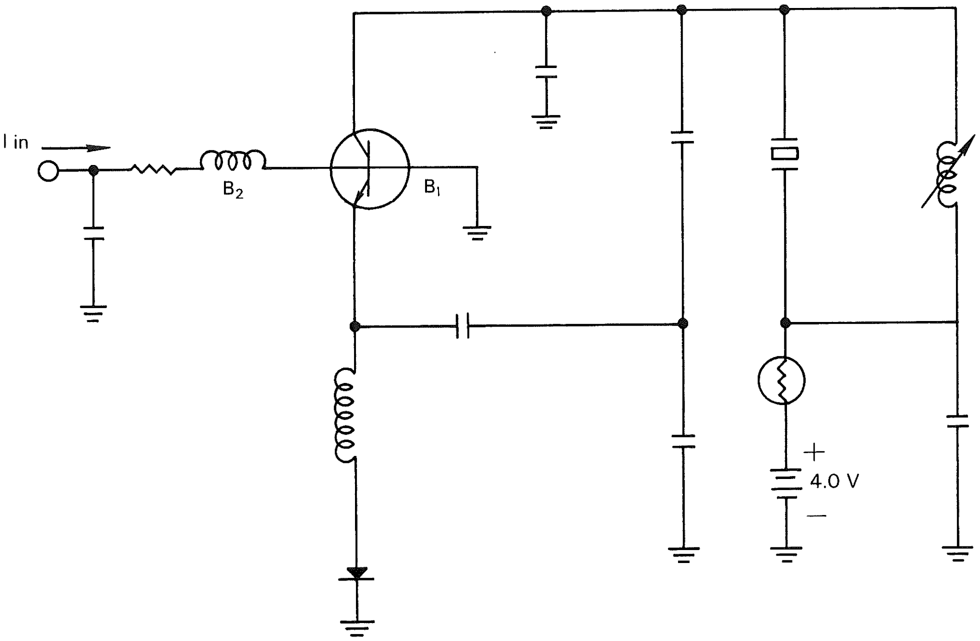
March 1965 Brief 65-10055

# NASA TECH BRIEF

## FM Oscillator Uses Tetrode Transistor



**The problem:** Most frequency-modulated oscillators require complex circuitry to achieve large frequency variations for a given input signal. This is because the reactive parameter being changed to achieve frequency control is masked by the shunting effect of relatively low fixed impedances.

**The solution:** A tetrode-driven crystal oscillator in which the frequency is controlled by variation of the second base ($B_2$) current of the tetrode operated in the reverse mode.

**How it's done:** The circuit uses a crystal as a resonating element in a standard feedback oscillator commonly in use. In normal operation, current flows out of $B_2$ and input capacitance is shunted by the low resistance of the forward-biased emitter-base diode. This effectively reduces the change in frequency that could otherwise be obtained by varying the input capacitance.

The circuit illustrated operates on the characteristic change in output capacitance achieved by causing $B_2$ current to flow in the direction opposite (toward or into $B_2$) flow in the normal mode. Collector bias is such that the thermistor regulates the collector-first base ($B_1$) voltage and thus the output capacitance to compensate for any decrease in frequency with temperature. In this mode, increases in $B_2$ current are used to change output capacitance and thus change frequency of oscillation.

(continued overleaf)

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**Notes:**

1. In one configuration used, average frequency control of 0.27 cps per microamp change has been achieved.
2. Using a variable frequency oscillator circuit (not crystal controlled), frequency variations of 0.25 mc at a 0.75-mc center frequency have been realized by increasing $B_2$ current from 150 to 200 microamps.
3. Inquiries concerning this innovation may be directed to:

Technology Utilization Officer
Jet Propulsion Laboratory
4800 Oak Grove Drive
Pasadena, California, 91103
Reference: B65-10055

**Patent status:** NASA encourages commercial use of this innovation. No patent action is contemplated.

Source: Donald W. Boensel
(JPL-82)

March 1965 Brief 65-10057

# NASA TECH BRIEF

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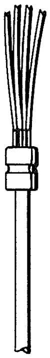
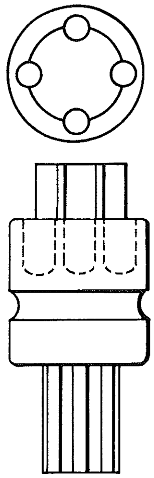
## Feed-Through Has Polyterminal Feature



STANDARD TERMINAL



POLYTERMINAL

**The problem:** Standard bifurcate terminals require a relatively large amount of solder for multiple connections, afford no visible inspection for connection integrity, and frequently suffer bond deterioration during changes to terminal connections.

**The solution:** A feed-through connector featuring individual solder pots in the polyterminal side.

**How it's done:** A polyterminal is designed as a feed-through to accommodate a single lead on one side and multiple leads on the other. The body of the polyterminal is splined for press fitting into a supporting member. The multiple terminal side is designed with from two to six individual solder pots that permit individual connection or disconnection of the separate conductors. Changes in circuitry are accomplished without disturbing other connections because they are not remelted. The individual solder pots provide good connections with relatively small amounts of solder and permit precise visual inspection of each bond.

**Notes:**

1. This design provides a friction mechanical bond to position the conductors prior to soldering—a valuable aid in assembly line work.
2. This polyterminal would improve any circuitry currently employing bifurcate terminals.
3. Inquiries concerning this innovation may be directed to:

   Technology Utilization Officer
   Marshall Space Flight Center
   Huntsville, Alabama, 35812
   Reference: B65-10057

**Patent status:** NASA encourages commercial use of this innovation. No patent action is contemplated.

Source: L. H. Sanders
(M-FS-25)
Category No. 01

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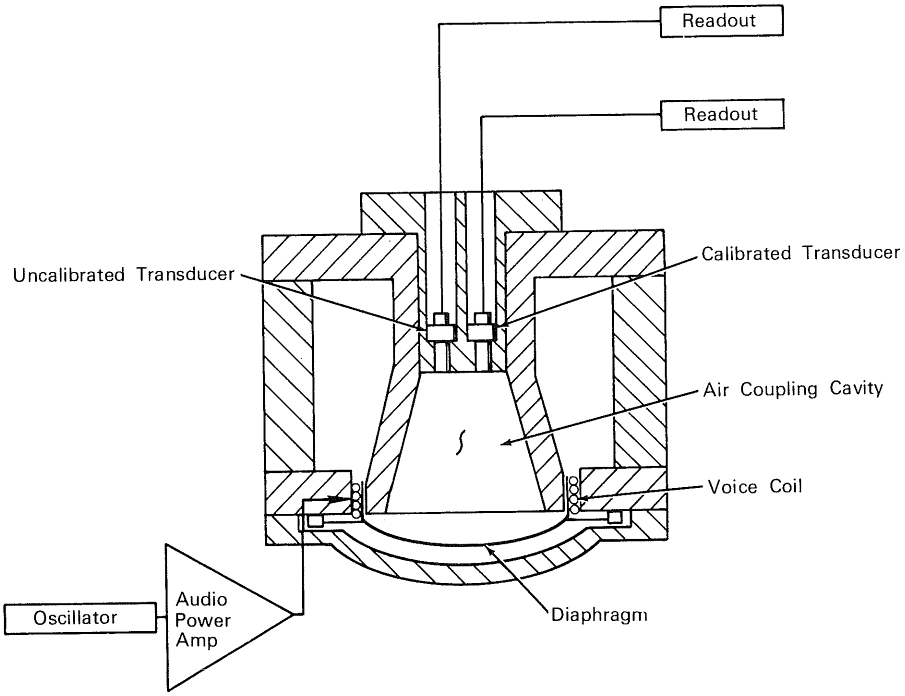
March 1965 Brief 65-10059

# NASA TECH BRIEF

## Metal Diaphragm Used to Calibrate Miniature Transducers



**The problem:** To develop a dynamic system for miniature pressure transducers over a sine-wave sound range to 160 decibels at frequencies of 200 to 100,000 cycles per second. Such high frequency response is rerequired of pressure transducers used in hypersonic test tunnel applications as well as in space vehicles during launch.

**The solution:** A dynamic comparative calibration system in which a calibrated transducer and an uncalibrated transducer are exposed to a single input at selected sound amplitudes and frequencies. It is a comparative system in which the unknown is calibrated by referring its readout to that of the known.

**How it's done:** An electromechanically-driven diaphragm is used to produce a sinusoidal sound pressure in the air coupling cavity. System frequency is determined by the oscillator and audio amplitude is controlled by the power amplifier. The use of a very lightweight metal diaphragm together with a minimum volume air chamber permits the generation of high sound-pressure levels to frequencies of 100,000 cps.

**Notes:**

1. The system measures only 12 inches by 12 inches and may be operated in a controlled atmosphere chamber at desired pressures greater or less than atmospheric.

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2. Inquiries concerning this innovation may be directed to:
   Technology Utilization Officer
   Marshall Space Flight Center
   Huntsville, Alabama, 35812
   Reference: B65-10059

**Patent status:** NASA encourages commercial use of this innovation. No patent action is contemplated.

Source: Astro-Space Laboratories, Inc. under
contract to Marshall Space Flight Center
(M-FS-207)

March 1965

Brief 65-10061

# NASA TECH BRIEF

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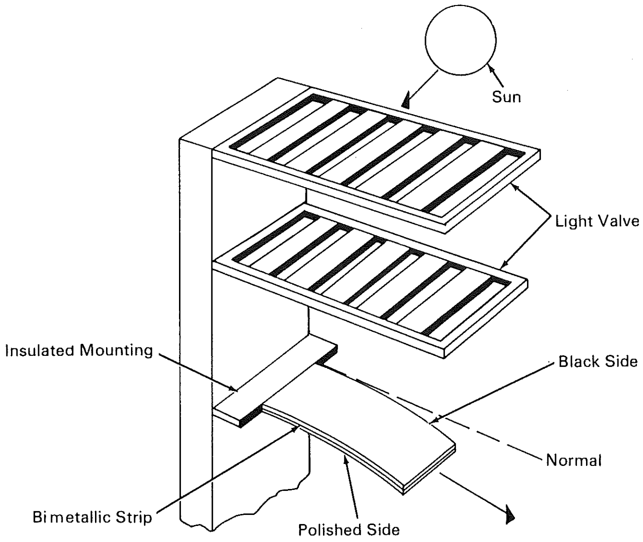
## Simple Control Device Senses Solar Position



**The problem:** Many systems are affected by the presence of solar radiation. In those systems adversely affected by such radiation beyond a certain level, it is necessary to adjust or shield equipment as the relative position of the sun changes. The amount of heat and light energy received by an area is a function of the angle of incidence of the sun's rays on that area. A simple and reliable device is needed to provide control actuations as a function of solar incidence.

**The solution:** A light valve that controls the amount of solar radiation incident on a specially prepared bimetallic strip. The axis of the light valve is oriented in the direction of normal solar motion as it relates to the system or equipment involved. Curvature of the bimetallic strip is a function of angle of solar incidence and may be used to actuate control mechanisms.

**How it's done:** The light valve consists of two sections, resembling venetian blinds, with transverse slots and slats of equal width. The two sections are stacked with axes parallel and are separated so as to provide 25% transmission of radiation at normal incidence. Transmission typically varies linearly from 0% to 50% with small deviations from normal incidence. The bimetallic strip is prepared with one black side and one highly polished side. The black, high-absorptivity side is faced toward the light valve and the polished, low-emissivity side is faced away, the whole being thermally insulated from its mounting. Angular change in position of the bimetallic strip is a function of the characteristics of the strip and light valve, the position of the sun, and time.

The important characteristics of the particular configuration used are its gain and time constant which are approximately 1/6 and 2500 seconds, respectively,

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with the solar intensity at earth distance from the sun. Although time constant is fairly easily understood, the concept of gain may need some clarification. Gain is the ratio of the steady state change in the angular movement at the tip of the bimetallic strip to the change in sun/actuator angle.

## Notes:

1. Sensitivity and dynamic range can be adjusted by varying the slot-to-slat ratio and the separation distance between the two venetian blind sections.
2. Characteristics such as gain and time constant can be adjusted by the selection of different sensitivity bimetallic elements or merely changing their physical size.
3. This device may find application where temperatures must be maintained under varying amounts of incident sunlight, such as greenhouses or modern office buildings with their vast expanses of single pane glass. It should be pointed out, however, that the device described was designed to operate in a vacuum; thermal isolation of the bimetallic strip is critical to its operation. Convection losses caused by a surrounding atmosphere may be significant and should be investigated further if this type of application is planned.
4. Inquiries concerning this invention may be directed to:

   Technology Utilization Officer
   Jet Propulsion Laboratory
   4800 Oak Grove Drive
   Pasadena, California, 91103
   Reference: B65-10061

**Patent status:** NASA encourages the immediate commercial use of this invention. Inquiries about obtaining rights for its commercial use may be made to NASA, Code AGP, Washington, D.C., 20546.

Source: James O. Lonborg and
James C. Randall
(JPL-638)

March 1965 Brief 65-10062

NASA TECH BRIEF

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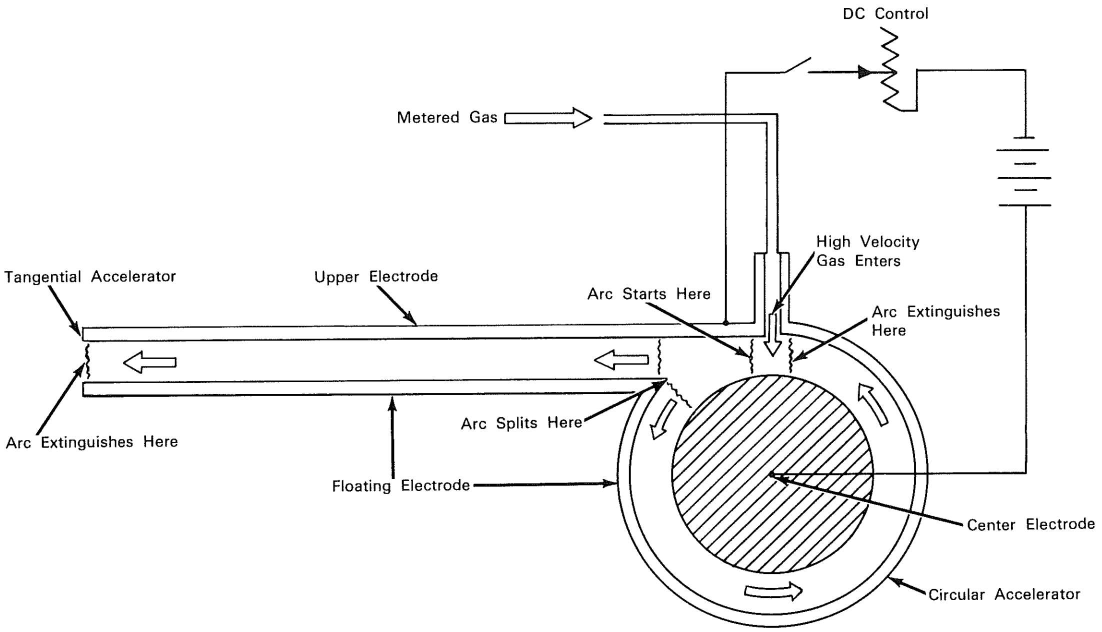
# Pulsed Plasma Accelerator Operates Repetitively Without Complex Controls



**The problem:** Designing a pulsed plasma accelerator that can operate repetitively with a wide variety of gases over a large range of pressures without the use of complex control equipment.

**The solution:** A dc-powered self-repeating pulsed plasma accelerator that combines a circular channel with a tangential channel at the entrance passage of a high-velocity gas. The walls of the accelerator are electrically conductive and serve as electrodes.

**How it's done:** The two electrodes formed by the upper section of the tangential accelerator and the center section of the circular accelerator are maintained at different potentials by the dc power supply. The bottom section of the tangential accelerator and the outer circumference of the circular accelerator serve as a floating electrode, which acts as a conductor when the plasma arc splits. The magnetohydrodynamic force is applied to the plasma stream by the dc field between the electrodes and a steady magnetic field (perpendicular to the plane of the paper) maintained within the channels from a separate source (not shown in the schematic diagram). The inside walls of the accelerator electrodes are made of a suitable refractory metal, and the annular spaces between the walls can be used for the circulation of a coolant.

In operation, the test gas is introduced into the system and the arc is started in a conventional manner, such as by placing a jumper between the top

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electrode of the tangential accelerator and the center electrode of the circular accelerator and then closing the switch. This action starts the arc which begins to rotate in the direction of the arrows within the circular accelerator. Once the arc begins to circulate, it breaks into two arcs, one arc traveling down the tangential accelerator and the other around the circular accelerator. The two arcs simultaneously reach the ends of both accelerators where they are extinguished. This operation completes one cycle and places an arc in the position for continued automatic high frequency cycling of the accelerator.

## Notes:

1. A variety of gases, including air, can be used to generate plasmas in this system; operating pressures and mass flows of the gases are not critical.
2. The spent plasma can be vented directly into the atmosphere, into an evacuated chamber, or into a channel designed to accelerate or decelerate the flow. When the accelerator operates at high pressures, an exit nozzle can be used to vent the gas at high velocity and low temperature.
3. The operational simplicity and negligible erosion of the electrodes recommend this accelerator for experimental aerodynamic and heat-transfer studies in an air atmosphere and as an arc heater.
4. Inquiries concerning this invention may be directed to:

Technology Utilization Officer
Langley Research Center
Langley Station
Hampton, Virginia, 23365
Reference: B65-10062

**Patent status:** NASA encourages the immediate commercial use of this invention. Inquiries about obtaining rights for its commercial use may be made to NASA, Code AGP, Washington, D.C., 20546.

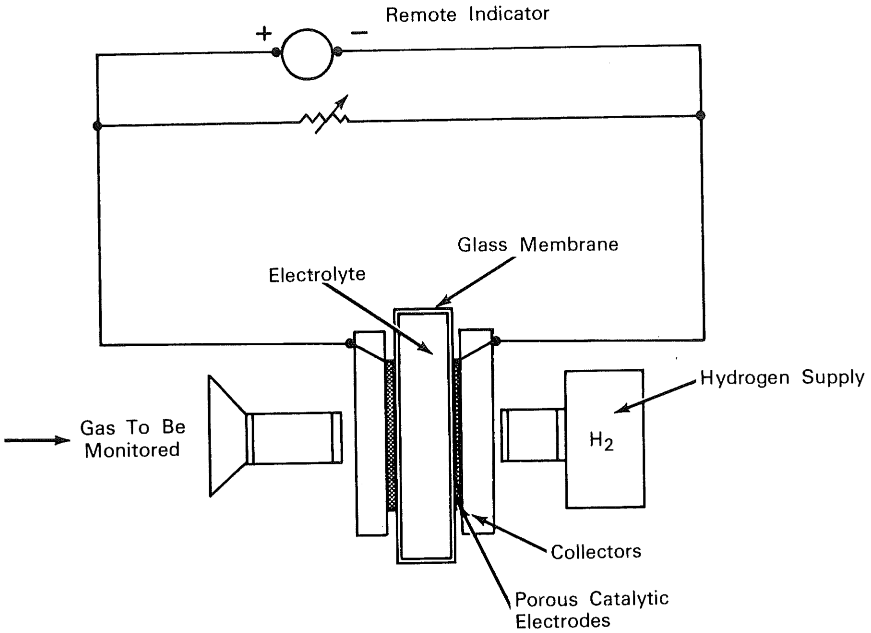
Source: Alexander P. Sabol
(Langley-48)

March 1965

Brief 65-10066

# NASA TECH BRIEF

## Fuel Cell Serves as Oxygen Level Detector



**The problem:** Where large quantities of oxygen supplies are stored it is essential to monitor the oxygen level in the air in order to detect any leakage and the rate of leakage. In closed environments such as mines, it is also desirable to monitor the oxygen level in the air in order to ensure a life-sustaining environment. In both instances it is frequently desirable to perform this monitoring from a remote location. Current chemical methods do not readily lend themselves to remote applications.

**The solution:** A fuel cell that responds to hydrogen and oxygen with an output voltage that is proportional to the partial pressure of these gases encountered. By exposing one electrode to a constant supply of hydrogen and the other electrode to the ambient, the partial pressure of oxygen in the ambient is calculated from the output voltage of the cell.

**How it's done:** The fuel cell uses sulfuric acid as the electrolyte contained in a round, cylindrical membrane made of a special glass, 0.06-inch thick. Stamped platinum black discs, 1/8-inch in diameter are used as the porous catalytic electrodes. The hydrogen necessary for the operation of the cell is provided from a standard supply source (flask, tank, etc.) while the oxygen is received from the ambient being sampled. The output voltage of the fuel cell is proportional to the amount of oxygen (partial pressure of $O_2$) in the sampled gas. The relationship between output

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voltage and partial pressure of $O_2$ is not linear but can be calibrated. Test curves show the instrument to be most sensitive at partial pressures of zero to 10 mm Hg and the output voltage to be more linear with pressure from 50 mm Hg up to the $O_2$ partial pressure equivalent of the earth's atmosphere at sea level. A saturation level was not reached in any test.

**Notes:**

1. This device could be used as an automatic control wherever oxygen content must be maintained at certain levels in enclosed areas.
2. The detector could serve as a warning device where quantities of oxygen are stored or are transferred by pipe in enclosed passages.
3. Inquiries concerning this innovation may be directed to:

Technology Utilization Officer
Jet Propulsion Laboratory
4800 Oak Grove Drive
Pasadena, California, 91103
Reference: B65-10066

**Patent status:** NASA encourages commercial use of this innovation. No patent action is contemplated.

Source: General Electric Company under
contract to Jet Propulsion Laboratory
(JPL-SC-072)

March 1965

Brief 65-10067

# NASA TECH BRIEF

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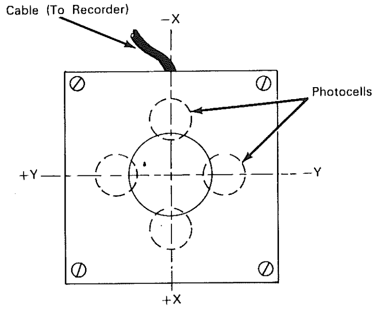
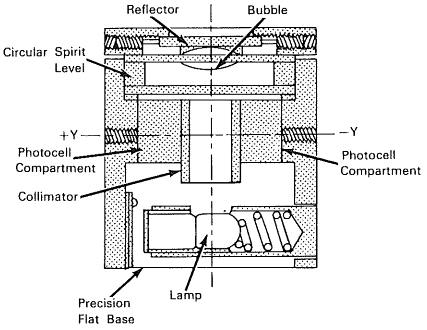
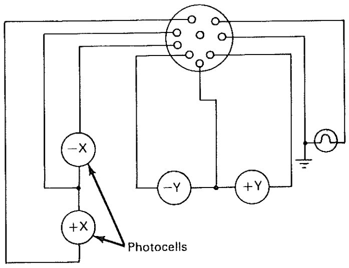
## Sensitive Level Sensor Made With Spirit Level, Gives Electrical Output



TOP VIEW





WIRING DIAGRAM

**The problem:** Devising a sensitive two-axis level sensor that will provide an electrical indication of the deviation of the level of a flat surface within ±15 seconds of arc.

**The solution:** A sensor incorporating a circular spirit level, a small electrical lamp, and two pairs of photocells connected in a bridge circuit. The sensor is packaged in a 1-1/4- × 1-1/4- × 1-1/2-inch steel container having a precision flat base which is placed on a horizontal surface to be leveled.

**How it's done:** The four photocells are mounted at the extremities of two orthogonal reference axes (+x, −x; +y, −y) lying in a plane parallel to the base of the container. Each pair of oppositely mounted photocells (one pair on the x−x axis and the other pair on the y−y axis) is connected as a half-bridge circuit. The small lamp near the base of the sensor is symmetrically mounted between the photocells. Light from this lamp passes up through a collimator to the circular spirit level and a concave reflector which are symmetrically mounted above the photocells. The bubble in the spirit level and the concave reflector constitute a lens system which reflects light from the lamp to the photocells.

In making a measurement, the base of the sensor is set on a horizontal precision flat surface to be leveled. When the bubble is centered, indicating a level condition, the photocell bridge is balanced and there is

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no electrical output. When the test surface deviates from level by more than ±15 seconds of arc, the bubble is displaced and different amounts of light are reflected to each of the photocells. As a result, the bridge is unbalanced and puts out a dc error voltage.

**Notes:**

1. The sensitivity of the device is basically dependent on the geometry of the spirit level.
2. This sensor can be easily converted into an automatic leveling system by incorporating conventional position servos.
3. This device should have application for remote leveling of machinery, automatic leveling of force-measuring instruments, leveling of surveying instruments, and leveling of vehicles in static test orientations.
4. Inquiries concerning this invention may be directed to:

Technology Utilization Officer
Langley Research Center
Langley Station
Hampton, Virginia, 23365
Reference: B65-10067

**Patent status:** NASA encourages the immediate commercial use of this invention. Inquiries about obtaining rights for its commercial use may be made to NASA, Code AGP, Washington, D.C., 20546.

Source: E. L. Bryant
(Langley-49)

March 1965

Brief 65-10068

NASA TECH BRIEF

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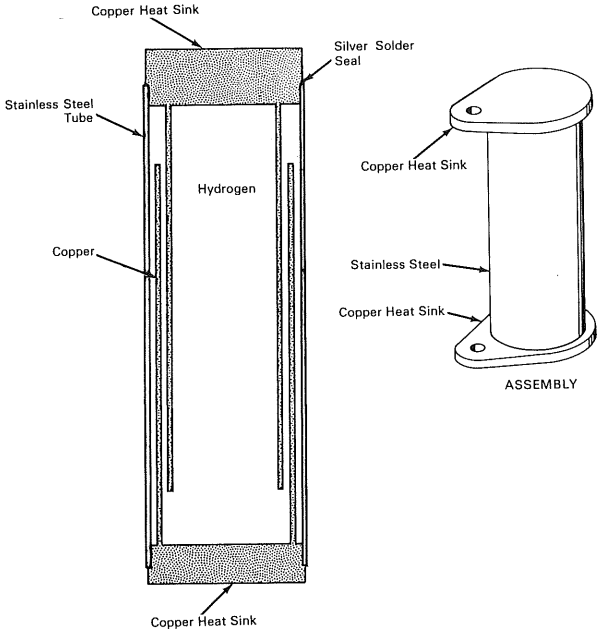
# Automatic Thermal Switch Accelerates Cooling-Down of Cryogenic System.



**The problem:** Providing an automatic switch that will accelerate the cooling of helium gas to below its inversion temperature (approximately 40° K) in the Joule-Thomson branch of a multistage helium liquefaction system and to 4° K in the final stage.

**The solution:** A hermetically sealed metal tube containing hydrogen gas under pressure. This device is a good thermal conductor at temperatures down to 10° K and a thermal insulator below this temperature.

**How it's done:** The switch employs a short stainless steel tube fitted with copper heat sinks at both ends. This assembly is pressurized with hydrogen and hermetically sealed with silver solder at the junction between the stainless steel tubing and the copper heat sinks.

The switch is a thermal conductor above 10° K, since at these temperatures heat can be transferred between the two copper sinks by conduction along the stainless steel tube and by convection through the hydrogen gas. Below this temperature, the hydrogen solidifies, leaving a hard vacuum in the tube, and the conductivity of the stainless steel is virtually zero. Therefore the switch becomes an excellent thermal insulator below 10° K. In operation in the helium liquefaction system, the thermal switch is connected between two stations where heat transfer must be effected to accelerate the cooling-down process.

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**Note:** Inquiries concerning this invention may be directed to:

Technology Utilization Officer
Jet Propulsion Laboratory
4800 Oak Grove Drive
Pasadena, California, 91103
Reference: B65-10068

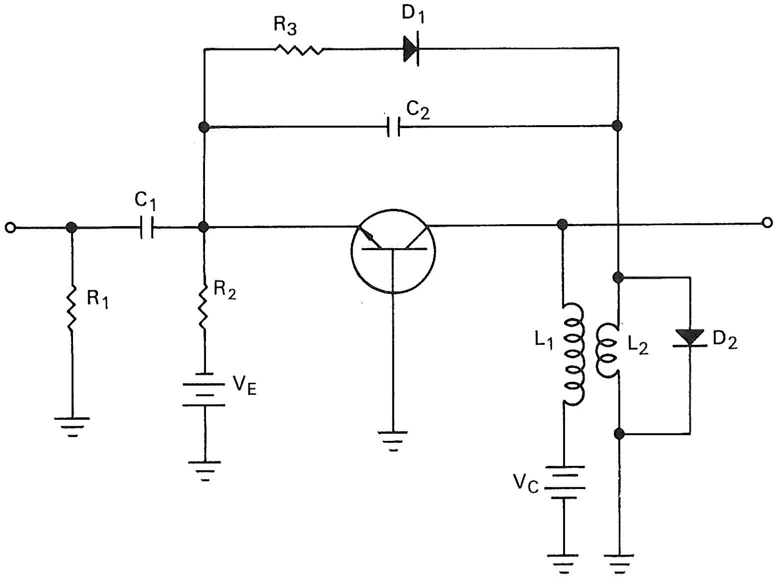
**Patent status:** NASA encourages the immediate commercial use of this invention. Inquiries about obtaining rights for its commercial use may be made to NASA, Code AGP, Washington, D.C., 20546.

Source: Ervin R. Wiebe
Jet Propulsion Laboratory
(JPL-655)

March 1965 Brief 65-10069

# NASA TECH BRIEF

## Feedback Oscillator Functions As Low-Level Pulse Stretcher



**The problem:** Providing a circuit capable of stretching narrow low-power trigger pulses. Conventional pulse stretching circuits used in computer memories require high-level trigger pulses. The low sensitivity of such circuits is due to the potential which must be overcome to trigger the oscillator. If the potential is reduced by forward biasing the oscillator, free-running oscillation will usually occur.

**The solution:** Forward biasing the transistor oscillator below the point of unity loop gain allows a low-level pulse to trigger the circuit without allowing free-running oscillation. The use of two parallel feedback loops improves the pulse stretching capabilities of the circuit.

**How it's done:** The pulse stretcher circuit is similar to a standard blocking oscillator. However, the high sensitivity (low trigger level) of this circuit is obtained by forward biasing the emitter-base junction of the transistor. By proper selection of $R_2$ and $V_E$, the collector bias current can be set to approximately 10 microamperes, thus keeping the loop gain below unity and preventing free-running oscillation.

When a negative input pulse is applied to the emitter of the transistor through $C_1$, the current in the collector circuit increases. As a result of this increase, a positive feedback voltage is coupled across coils $L_1$ and $L_2$, through capacitor $C_2$, to the emitter of the transistor. This positive feedback continues until the voltage across $L_2$ is sufficient to turn on diode $D_1$. The use of secondary feedback path $D_1-R_3$ permits pulse widths exceeding the charge time of capacitor $C_2$.

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In addition, the secondary feedback path allows the use of a smaller value capacitor for $C_2$ which increases the recovery time of the circuit. A faster recovery time also results from the inclusion of swamping diode $D_2$ across coil $L_2$.

**Notes:**

1. The approximate trigger requirements for such a circuit are a signal 30 nanoseconds wide at a level of 200 microamperes and 70 millivolts. Output pulses of 0.5-microsecond duration can be expected from this circuit.
2. This circuit should be of interest to manufacturers of electronic pulse equipment, particularly for use in very-low-power digital computers.
3. Inquiries concerning this innovation may be directed to:

   Technology Utlization Officer
   Goddard Space Flight Center
   Greenbelt, Maryland, 20771
   Reference: B65-10069

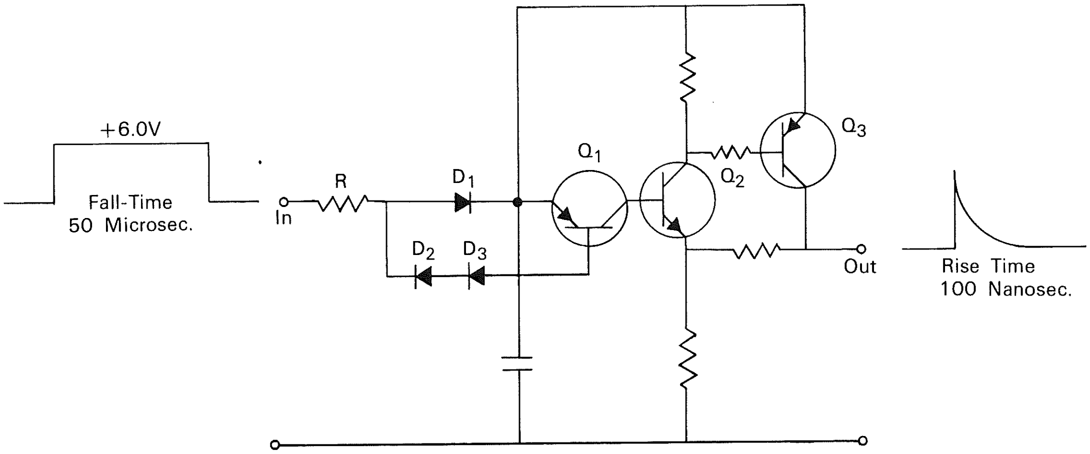
**Patent status:** NASA encourages commercial use of this innovation. No patent action is contemplated.

Source: Sperry Rand Corporation
under contract to Goddard Space Flight Center
(GSFC-261)

March 1965 Brief 65-10072

# NASA TECH BRIEF

## Synchronized Pulse Generator Needs No External Power



**The problem:** Devising a circuit that does not require the use of external power to generate a fast rise-time pulse synchronized with an input pulse of relatively slow rise and fall times.

**The solution:** A simple circuit having a high input impedance and a low output impedance.

**How it's done:** The diagram illustrates the circuit for generating a positive pulse during the fall time of the rectangular input pulse, which swings to zero from an amplitude of +6.0 volts. During the time the input pulse remains at this amplitude, charging current flows into the capacitor through the input resistor R and diode $D_1$. A large input impedance is obtained by making R large. By proper choice of the capacitance value, the capacitor will charge to approximately +6.0 volts in the time the input pulse remains at this voltage. In this time interval, all transistors are biased off so that the capacitor retains its charge. When the input signal drops from +6.0 volts to approximately +4.0 volts, so that diodes $D_2$ and $D_3$ are forward biased, transistor $Q_1$ conducts and puts out a signal which turns on amplifier stage $Q_2$-$Q_3$ to yield a sharply rising pulse. The effective supply voltage for the amplifier is obtained from the charge on the capacitor which drains exponentially through transistors $Q_2$ and $Q_3$ to produce a corresponding exponential fall in the output pulse.

**Notes:**

1. The circuit described above yields an output at the fall time of the input signal. An output may be obtained on the rise time of a negative going pulse by use of NPN transistors for $Q_1$ and $Q_3$, a PNP transistor for $Q_2$, and by reversing the polarity of diodes $D_1$, $D_2$, and $D_3$.
2. The point during the fall or rise time of the input signal at which an output pulse is obtained is determined by the forward voltage drop across diodes $D_2$ and $D_3$. This point may be varied by

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changing the number of diodes used in the $D_1$-$D_2$ position, or it may be made very stable by replacing these diodes with a zener diode.

3. A tunnel diode may be incorporated into the circuit for operation on an input pulse with a single polarity swing or an input pulse with a positive-to-negative swing.
4. Inquiries concerning this invention may be directed to:

    Technology Utilization Officer
    Goddard Space Flight Center
    Greenbelt, Maryland, 20771
    Reference: B65-10072

**Patent status**: NASA encourages the immediate commercial use of this invention. Inquiries about obtaining rights for its commercial use may be made to NASA, Code AGP, Washington, D.C., 20546.

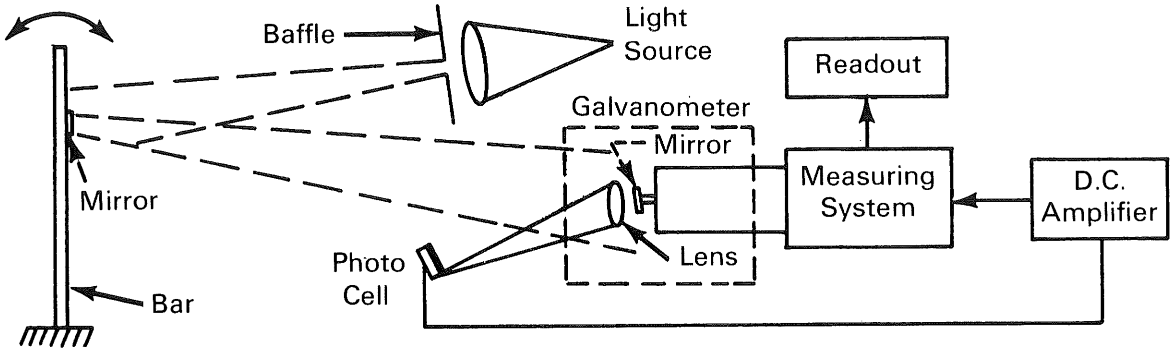
Source: Ciro A. Cancro and Paul J. Janniche, Jr.
(GSFC-274)

March 1965

Brief 65-10073

# NASA TECH BRIEF

## System Measures Angular Displacement Without Contact



**The problem:** To accurately measure the angular displacement of an object without the use of electrical or mechanical connection to the object.

**The solution:** A system of optics coupled to an electronic detection and measuring system whereby angular movement of reflected light is converted to a direct readout.

**How it's done:** The measuring system is based on the well-known optical lever principle and uses a photocell, amplifier, and galvanometer to provide the electrical readout. A mirror mounted on the test object under observation reflects light from a fixed source to the detection system. As the object vibrates or rotates, the light beam reflected from the attached mirror sweeps through an angle equal to twice the angle by which the object is displaced. This light beam is reflected from a second mirror and focused on the edge of a photocell. The second mirror is mounted on a galvanometer and its attitude is a function of galvanometer current. A change in the angle of the test object causes a corresponding change in the amount of light striking the photocell and thus a change in the output current of the photocell. This current is fed to the amplifier, measuring system, and readout and is used to deflect the galvanometer mirror to maintain the light beam in a position locked on the edge of the photocell. The current flowing through the loop is therefore a measure of the angle of the test object.

**Notes:**

1. This system has given accurate measurements to within 0.1 percent over a frequency range from dc to several thousand cps.
2. In conjunction with servos, this system could be used effectively to maintain relative attitude of two or more items in severe environments.
3. Application examples include fatigue tests in vacuum chambers, flutter research, damping measurements, and control systems requiring deflection input.

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4. Inquiries concerning this invention may be directed to:
Technology Utilization Officer
Langley Research Center
Langley Station
Hampton, Virginia, 23365
Reference: B65-10073

**Patent status:** NASA encourages the immediate commercial use of this invention. Inquiries about obtaining rights for its commercial use may be made to NASA, Code AGP, Washington, D.C., 20546

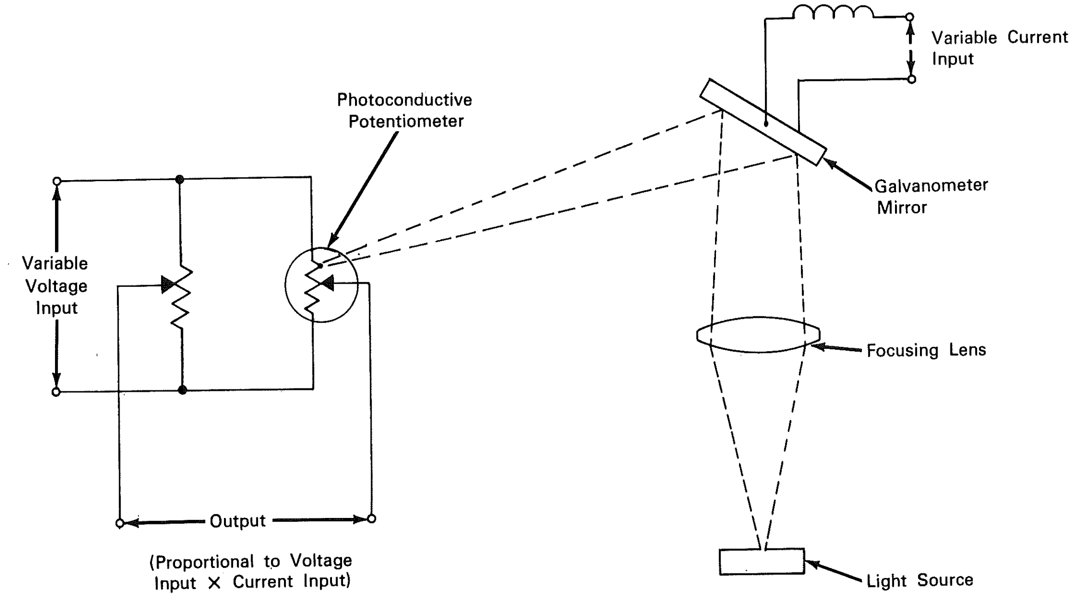
Source: W. T. Davis
(Langley-46)

March 1965

Brief 65-10076

# NASA TECH BRIEF

## Light-Sensitive Potentiometer Measures Product of Two Variables



**The problem:** Providing an electrical circuit whose voltage output will be an accurate measure of the product of two variables represented by electrical inputs to the circuit (e.g., voltage and current). Hall effect multipliers, various meter movements, and mechanical servo systems used to form the product of two variables are subject to inaccuracies due to hysteresis, changes in reluctance, mechanical friction, contact resistance, and noise.

**The solution:** A circuit using a photoconductive (light-sensitive) potentiometer in conjunction with a beam of light reflected from a galvanometer mirror.

**How it's done:** The photoconductive potentiometer is mounted so that a focused beam of light reflected from the galvanometer mirror controls the resistance of the potentiometer. The output voltage from the potentiometer circuit is therefore directly proportional to the product of the input voltage across the potentiometer and the galvanometer current.

**Note:** Inquiries concerning this invention may be directed to:

Technology Utilization Officer
Goddard Space Flight Center
Greenbelt, Maryland, 20771
Reference: B65-10076

**Patent status:** NASA encourages the immediate commercial use of this invention. Inquiries about obtaining rights for its commercial use may be made to NASA, Code AGP, Washington, D.C., 20546.

Source: Oscar C. Haertsch
(GSFC-240)
Category No. 01

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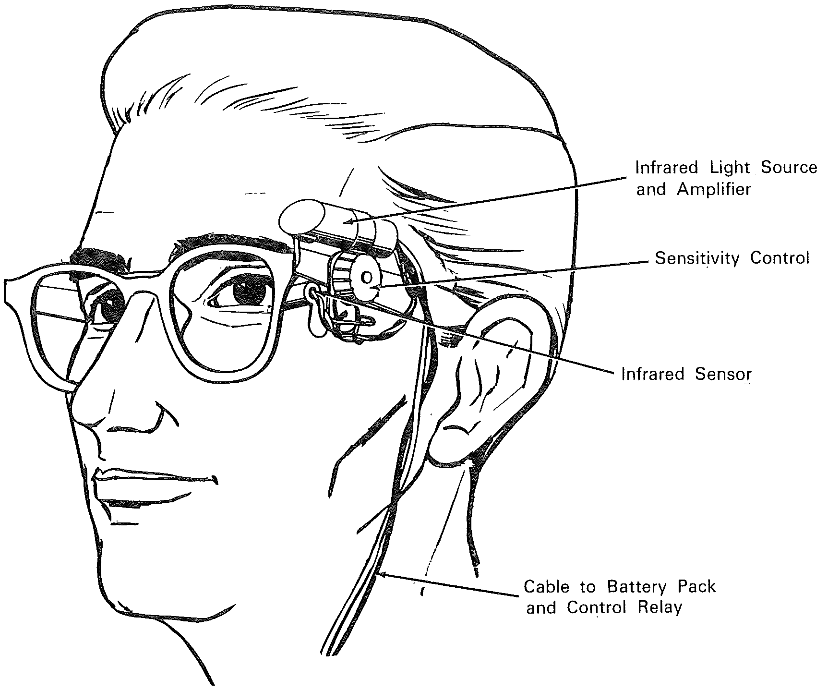
March 1965 Brief 65-10079

# NASA TECH BRIEF

## Photoelectric Sensor Output Controlled By Eyeball Movements


Infrared Light Source and Amplifier
Sensitivity Control
Infrared Sensor
Cable to Battery Pack and Control Relay

**The problem:** NASA research in the areas of bioscience and biotechnology has included a number of studies to devise methods of utilizing certain voluntary physiological functions (extracted output) for communicating or for controlling external operations. One of these studies has been directed to devising a means of extracting useful signals from the self-controlled movements of the human eye.

**The solution:** A small device combining an infrared (IR) source and sensor that can be attached to eyeglass frames or a headband. Operation of the device depends on the difference in IR absorption between the iris, which is a relatively good absorber, and the surrounding area of the eyeball, which reflects a relatively high percentage of the incident IR energy.

**How it's done:** The device incorporates an IR source, consisting of a battery-powered 6-volt or 10-volt lamp and high pass infrared filter (to filter out visible light from the lamp), and a cadmium selenide IR sensor. A filter is also placed in front of the IR sensor to exclude all ambient visible light. The IR source and sensor are mounted relative to one another so that when the eye is looking straight ahead all of the IR radiation from the source is incident on the

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area of the eyeball lying on one side of the iris and the radiation on this area is reflected to the sensor. This is the normal or off condition of the device. When the iris is voluntarily turned toward the IR source, a high percentage of the radiation is absorbed by the iris, and the external control relay connected to the sensor is actuated. An amplifier is used to amplify the current generated by the IR sensor. A sensitivity control connected to the amplifier permits adjustment of the threshold value for proper switching action under different ambient lighting conditions.

**Note:**

1. Inquiries concerning this innovation may be directed to:

Technology Utilization Officer
Marshall Space Flight Center
Huntsville, Alabama, 35812
Reference: B65-10079

**Patent status:** NASA encourages the immediate commercial use of this invention. Inquiries about obtaining rights for its commercial use may be made to NASA, Code AGP, Washington, D.C., 20546.

Source: Spaco, Inc., under contract to
Marshall Space Flight Center
(M-FS-274)

March 1965 Brief 65-10080

# NASA TECH BRIEF

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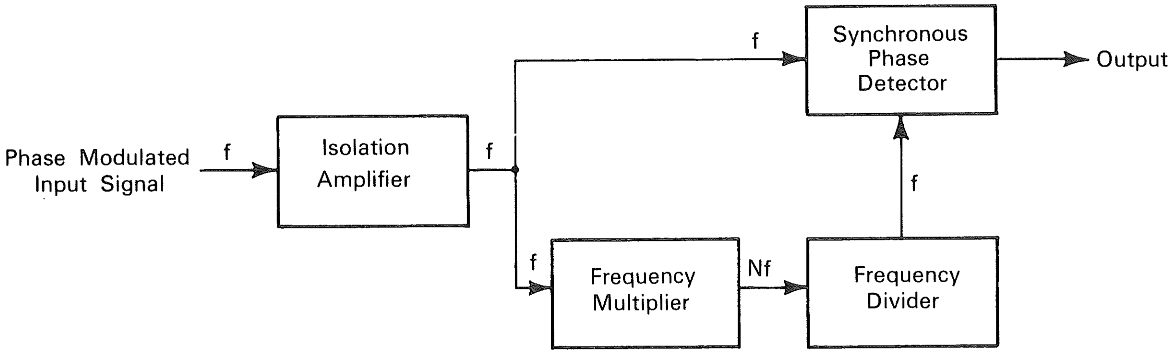
## Phase Detector Circuit Synthesizes Own Reference Signal



**The problem**: Detecting discrete-step, phase-modulated signals without using an external reference signal, complex internal timing circuits, or synchronized timing between the transmitter and receiver.

**The solution**: A phase detection circuit which synthesizes its phase reference signal from the phase-modulated input signal.

**How it's done**: The output of the isolation amplifier (at the input frequency f) is connected to both the frequency multiplier and the synchronous detector. The frequency multiplier uses the signal from the isolation amplifier as a control timing signal to generate an output at N times the input frequency. The multiplication factor, N, for a particular system is determined from the expression $N = 2\pi/\Delta\phi$, where $\Delta\phi$ is the phase change per step in radians. A frequency multiplier is used because phase changes in the input signal do not appear in the multiplier output.

The output of the frequency multiplier (at a frequency Nf), goes to the frequency divider, where, after division by N, a constant-phase signal of frequency f is available for use as the reference signal in the synchronous detector. The synchronous detector compares the phase of the original signal from the isolation amplifier with the phase of the synthesized reference signal. The output of the detector is a dc voltage, the polarity of which changes each time the input signal changes phase.

**Notes:**

1. It is necessary that the pulse rate and the carrier of the transmitted signal (e.g., from a telemeter) be synchronized so that the phase change (from modulation) always occurs at the same point on the carrier wave shape.
2. In a bi-phase modulation system, where digital information is transmitted in steps of 180° phase difference ($\Delta\phi = \pi$), the multiplication factor, N, is equal to 2.
3. Inquiries concerning this innovation may be directed to:

Technology Utilization Officer
Marshall Space Flight Center
Huntsville, Alabama, 35812
Reference: B65-10080

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**Patent status:** NASA encourages commercial use of this innovation. No patent action is contemplated.

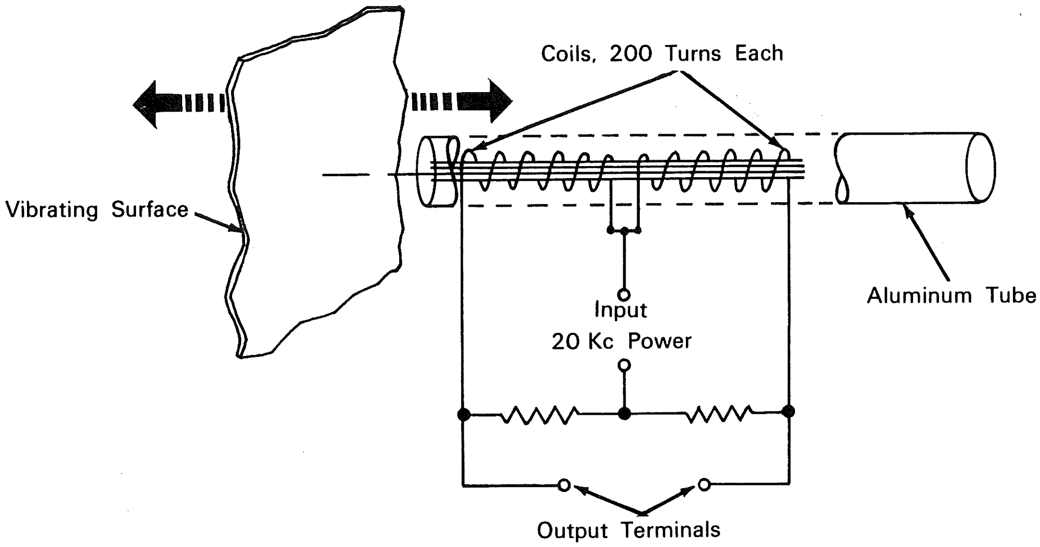
Source: Fairchild Stratos Corporation
under contract to Marshall Space Flight Center
(M-FS-247)

March 1965

Brief 65-10085

# NASA TECH BRIEF

## Transducer Senses Displacements of Panels Subjected to Vibration



**The problem:** Measuring the surface displacements of nonferrous metal panels subjected to vibration or flutter such as produced by high-velocity winds. The transducer to be used for the measurements must not be placed in physical contact with any portion of the test panel.

**The solution:** An inductive vibration sensor, 0.25 inch in diameter by 2 inches in length, that can be positioned 0.02 to 0.7 inch from the surface of a nonferrous metal panel.

**How it's done:** The sensor employs a simple circuit consisting of two counter-wound coils on a common core enclosed in an aluminum tube. A bridge circuit is formed by the addition of two resistors of equal value. Electrical power is supplied to the unit by a commercially available 20 kc signal generator. The input and output leads must be individually shielded. The coil at the sensing end, placed in proximity to the test surface, varies in inductance as the surface vibrates. The opposite coil is not affected and serves as a stable reference. The device has a flat frequency response of 1 kc and produces a voltage output which varies approximately as the inverse square of the distance of the sensing end of the coil from the panel surface. Because of the nonlinear characteristic of the sensor, a calibration curve is needed for each position relative to the surface where a null point is established. The device can detect a displacement of 0.00002 inch when it is positioned at 0.05 to 0.1 inch from a surface. When the

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device is positioned at a distance of 0.5 to 0.7 inch from the surface, its detection capability decreases to 0.002 inch.

**Notes:**

1. The sensor can best measure surface displacements in a flat plate of nonferrous metal that is a moderately good electrical conductor and more than 0.005-inch thick. It can also be used to a limited extent for ferrous metals and surfaces of unsymmetrical configuration.
2. Inquiries concerning this innovation may be directed to:

Technology Utilization Officer
Ames Research Center
Moffett Field, California, 93523
Reference: B65-10085

**Patent status:** NASA encourages commercial use of this innovation. No patent action is contemplated.

Source: Richard O. Pea
(ARC-37)

March 1965

Brief 65-10086

# NASA TECH BRIEF

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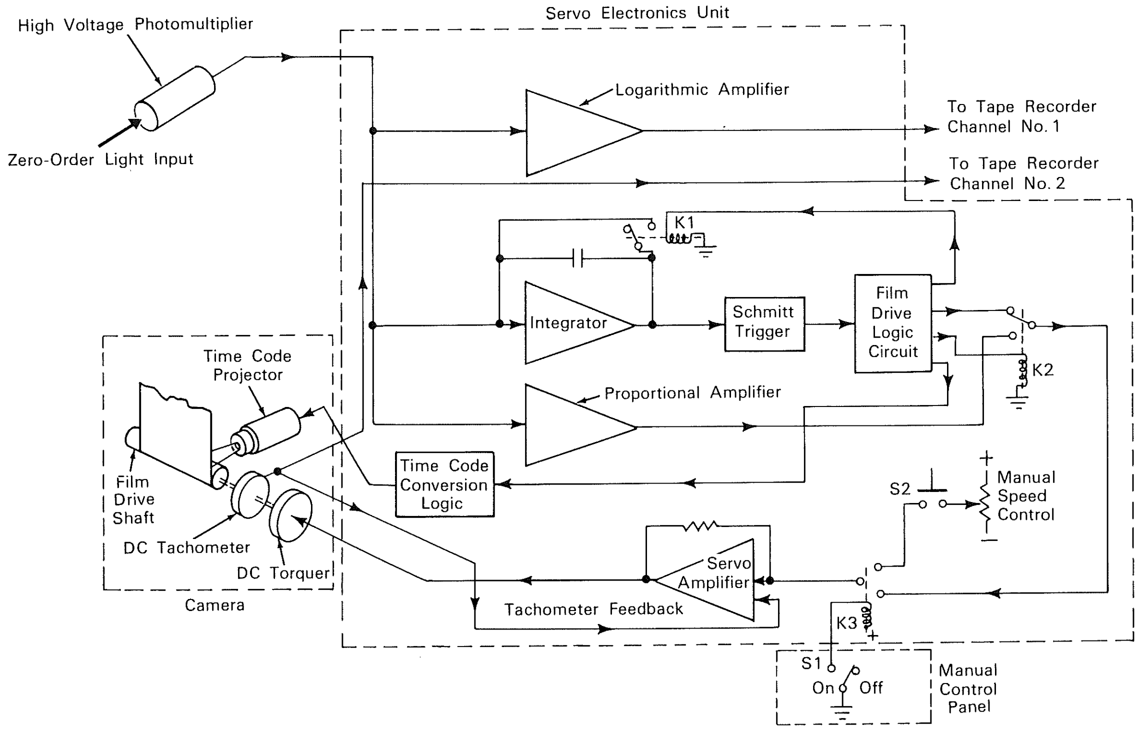
## System Selects Framing Rate for Spectrograph Camera


High Voltage Photomultiplier
Zero-Order Light Input
Servo Electronics Unit
Logarithmic Amplifier
To Tape Recorder Channel No. 1
To Tape Recorder Channel No. 2
K1
Integrator
Schmitt Trigger
Film Drive Logic Circuit
K2
Proportional Amplifier
Time Code Projector
Film Drive Shaft
DC Tachometer
DC Torquer
Camera
Time Code Conversion Logic
S2
Manual Speed Control
Servo Amplifier
Tachometer Feedback
K3
S1
On
Off
Manual Control Panel

**The problem:** Automatically advancing the film in a spectrograph camera at the correct framing rate corresponding to the intensity of the incoming diffracted light.

**The solution:** A servo system that uses zero-order light as a monitor of the incoming radiation to provide an error signal which controls the step advance and continuous driving rate of the film through the camera.

**How it's done:** The zero-order light reflected to the photomultiplier within the spectrograph assembly provides a direct current output which is proportional to the light intensity on the photomultiplier cathode. The dc output is applied in parallel to a logarithmic amplifier, an integrator, and a proportional amplifier. The logarithmic amplifier supplies a signal, equal in amplitude to the logarithm of the photomultiplier output, to channel 1 of the tape recorder. During periods when the light input to the photomultiplier is of low intensity, the dc signal to the integrator is integrated to provide an increasing stepping voltage which is applied to the Schmitt trigger circuit. The output from this circuit is fed to the film-drive logic

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circuit. If after a period of 3 seconds, the integrated voltage is insufficient to trigger the Schmitt circuit, an output pulse from the film-drive logic circuit actuates relay K1. This action shorts out the integrator capacitor, and initiates a new integration period. At the same time, a voltage pulse is applied through the servo amplifier to drive the film through 1/2 inch of travel. This cycle occurs every 3 seconds as long as the integrated output is insufficient to trigger the Schmitt circuit.

As the light intensity on the photomultiplier increases, the output of the integrator reaches a higher voltage level in a shorter period of time. As a consequence, the Schmitt circuit provides more frequent output pulses through the film-drive logic circuit to drive the film 1/2 inch and to reset the integrator. When the light intensity is sufficient to trigger the Schmitt circuit every 0.2 second or faster, the output of the film-drive logic circuit energizes relay K2. When this occurs, the output from the photomultiplier is fed through the proportional amplifier to drive the film at a rate proportional to the light intensity. If the light intensity drops so that the Schmitt circuit is triggered at a rate slower than every 0.2 second, relay K2 is deenergized and the film is driven at the pulse rate again, with a minimum speed of 1/2 inch every 3 seconds.

The output of the servo amplifier drive system is applied to the dc torque motor on the film drive shaft. A dc tachometer, also connected to this shaft, provides a rate feedback signal to the servo amplifier input when the film is being driven at a proportional rate. The tachometer signal is also applied to channel 2 of the tape recorder as the film-speed indication.

The film speed can also be controlled by the manual film-speed control. With the camera control switch S1 set to *OFF*, relay K3 is deenergized. The pushbutton S2 is held down, and a control potentiometer is adjusted to vary the control signal to the servo amplifier input.

## Note:

Inquiries concerning this innovation may be directed to:

Technology Utilization Officer
Langley Research Center
Langley Station
Hampton, Virginia, 23365
Reference: B65-10086

**Patent status:** NASA encourages the immediate commercial use of this invention. Inquiries about obtaining rights for its commercial use may be made to NASA, Code AGP, Washington, D.C., 20546.

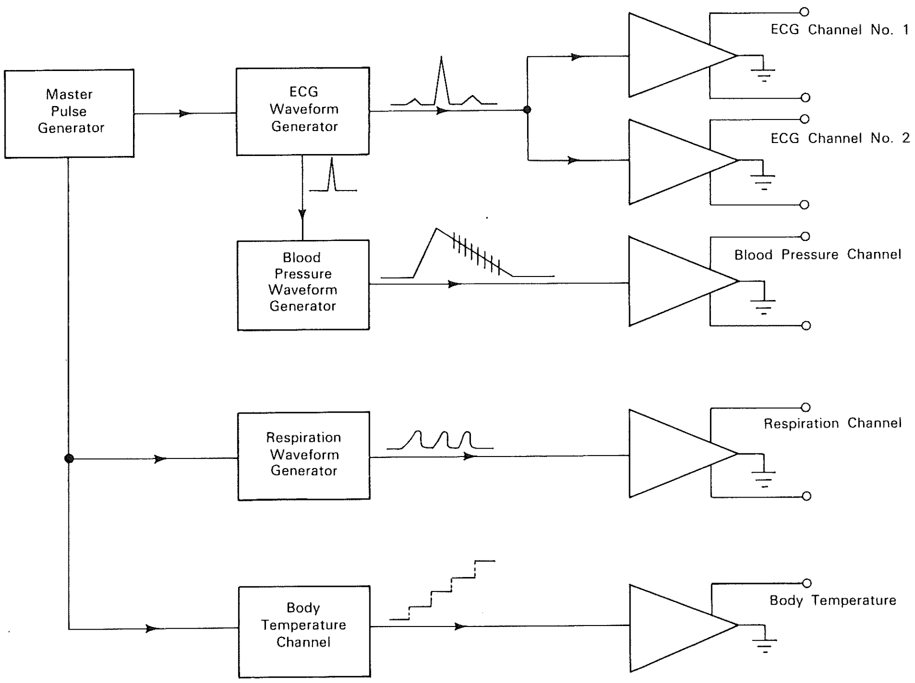
Source: American Optical Company
under contract to Langley Research Center
(Langley-55)

March 1965

Brief 65-10091

# NASA TECH BRIEF

## Simulator Produces Physiological Waveforms


Master Pulse Generator
ECG Waveform Generator
Blood Pressure Waveform Generator
Respiration Waveform Generator
Body Temperature Channel
ECG Channel No. 1
ECG Channel No. 2
Blood Pressure Channel
Respiration Channel
Body Temperature

**The problem:** In the space program, a need existed for an instrument capable of simulating various physiological waveforms at voltage and impedance levels compatible with manned spacecraft telemetry systems. Because of the very low frequency (down to 0.17 cps) components and dc voltage levels involved, conventional magnetic tape systems do not fulfill this need.

**The solution:** A physiological waveform simulator that produces signals closely approximating those normally picked up by biosensors attached to the human body.

**How it's done:** The master pulse generator feeds the electrocardiogram (ECG) channels a triangular waveform continuously variable from approximately 35 to 85 beats-per-minute. Monostables in the ECG channels produce fixed-duration square waves. These actuate final wave generators, which, in conjunction with a mixer and trimming potentiometer, feed the two differential amplifiers. The respective outputs are used to simulate an axillary electrocardiogram (ECG No. 1) and a sternal electrocardiogram (ECG No. 2).

An output from the ECG channels feeds the blood pressure channel to produce a composite signal that

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is applied to the differential amplifier, the output of which is manually adjustable. The resultant output signal is used to simulate the normal human blood pressure waveform.

For the respiration rate channel, the master pulse generator is an astable (free running) multivibrator. The repetition rate of this waveform is controlled by a three-position switch. After wave shaping by an R-C network, the waveforms are fed to a differential amplifier that controls the signal amplitude and processes the signal to a form compatible with the telemetry system being used. The output of the differential amplifier is used to simulate three human respiration rates, normal under certain discrete stimuli.

The body temperature channel is a high-level, single-ended channel providing dc voltage levels corresponding to six simulated body temperatures—95°, 97°, 99°, 101°, 103°, and 105° F—manually selected by a switch. Simulation of body temperature by manually selecting a voltage analog rather than using a continuous staircase sweep effects a substantial reduction in circuit complexity.

**Notes:**

1. This simulator could be used effectively in hospitals, medical research institutes, and medical schools for the propagation and study of typical physiological waveforms and for the checkout of biomedical instrumentation.
2. Inquiries concerning this innovation may be directed to:

   Technology Utilization Officer
   Manned Spacecraft Center
   P.O. Box 1537
   Houston, Texas, 77001
   Reference: B65-10091

**Patent status:** NASA encourages commercial use of this innovation. No patent action is contemplated.

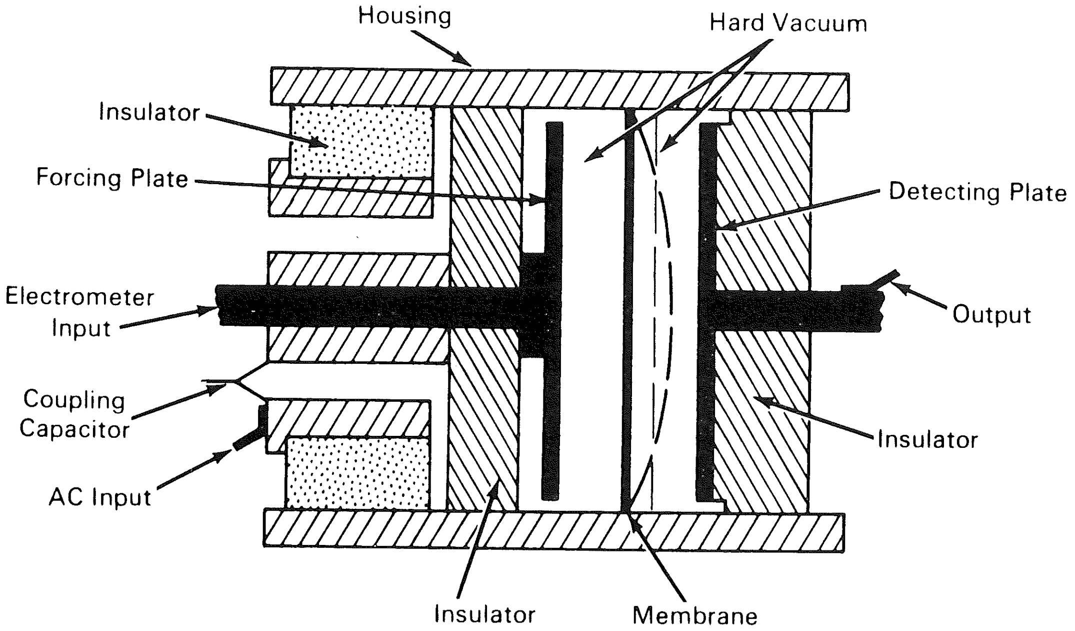
Source: Stig Ekeroot
(MSC-94)

April 1965

Brief 65-10056

# NASA TECH BRIEF

## Vibrating-Membrane Electrometer Has High Conversion Gain



**The problem:** Devising a technique that would allow measurement of currents below $10^{-17}$ ampere in a small, rugged transducer with high conversion gain and minimum internal power consumption.

**The solution:** An instrument employing a vibrating-membrane transducer in a circuit that utilizes its characteristics to provide a conversion gain three orders of magnitude greater than that of present electrometer transducers.

**How it's done:** The electrometer embodies a combination of mechanical and dynamic capacitance principles. Basically, the membrane is driven at its resonant frequency by an electrostatic force which is derived from voltages applied between the membrane and a stationary forcing plate in close proximity to one side of the membrane. The electrometer input current controls the displacement amplitude and affects the capacitance which is developed through the mechanical resonant properties of the membrane to provide a high conversion gain. This is accomplished with a drive voltage of two components: the first, a large sinusoidal voltage at resonant frequency, 90° out of phase to the membrane motion; and the second, a steady voltage derived from the small input current to be measured. A high conversion gain is obtained by using the voltage from a small input current as a dc voltage to control the membrane displacement amplitude when driven at its resonant frequency. Since the

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transducer has an excellent arrangement for shielding, high voltage may be applied to its detecting side to provide a large ac output signal. The result is an amplified sinusoidal voltage which is proportional to the high mechanical Q of the membrane. The electrometer is capable of conversion gains of $2 \times 10^{3}$ in voltage and $2 \times 10^{12}$ in current, giving a $4 \times 10^{15}$ power conversion gain.

**Notes:**

1. A model using this technique was constructed; it has an input impedance of better than $10^{16}$ ohms and is sensitive to less than one millivolt impressed on the forcing plate from the low-impedance source. The results of initial tests indicate that a compact, rugged instrument can be developed capable of measuring currents smaller than $10^{-17}$ ampere with low internal power consumption.
2. Inquiries concerning this invention may be directed to:

   Technology Utilization Officer
   Ames Research Center
   Moffett Field, California, 94035
   Reference: B65-10056

**Patent status:** NASA encourages the immediate commercial use of this invention. Inquiries about obtaining rights for its commercial use may be made to NASA, Code AGP, Washington, D.C., 20546.

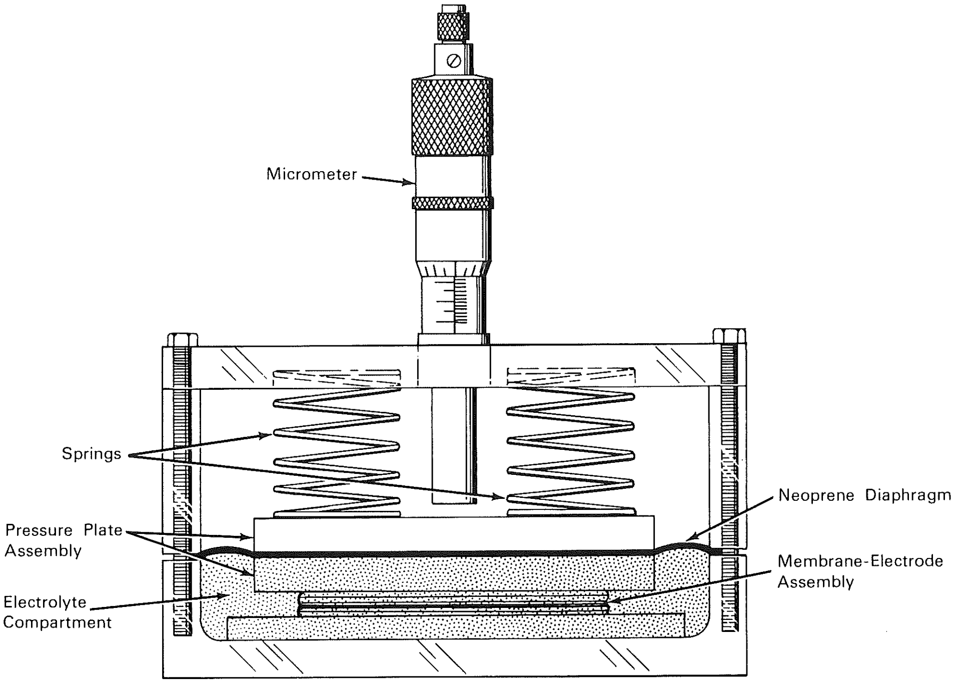
Source: John Dimeff and Grant W. Coon,
(ARC-38)

April 1965

Brief 65-10087

# NASA TECH BRIEF

## Apparatus Measures Swelling of Membranes in Electrochemical Cells



**The problem:** To measure with a high degree of accuracy the swelling characteristics of polymer membranes used as electrode separators in alkaline electrochemical cells. Existing testing methods are incapable of accurately measuring the amount of swelling and the force exerted by the expanded membrane against the cell walls. These characteristics must be accurately controlled in order to ensure optimum cell operation.

**The solution:** A measuring apparatus that includes four springs of known spring constant, a pressure-plate unit, and a micrometer caliper head.

**How it's done:** A dry membrane-electrode assembly is placed beneath the pressure plate in the apparatus and the micrometer is adjusted to obtain a zero reading of the thickness of the membrane-electrode assembly and the spring compression. The compartment containing the assembly is then filled with the electrolyte solution and placed under vacuum (5″ of Hg) to rid the assembly of entrapped air. When the system reaches equilibrium (after release of the vacuum), the micrometer reading gives a measure of the expansion or swelling of the membrane and the compression of the springs. The force exerted by the

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membrane assembly is computed from the micrometer readings and the value of the spring constant.

## Notes:

1. This apparatus should be of value to designers of electrolytic cells or other devices where the swelling characteristics of membranes must be accurately controlled.
2. Inquiries concerning this invention may be directed to:

   Technology Utilization Officer
   Goddard Space Flight Center
   Greenbelt, Maryland, 20771
   Reference: B65-10087

**Patent status:** NASA encourages the immediate commercial use of this invention. Inquiries about obtaining rights for its commercial use may be made to NASA, Code AGP, Washington, D.C., 20546.

Source: Thomas J. Hennigan
(GSFC-280)

April 1965 Brief 65-10089

# NASA TECH BRIEF

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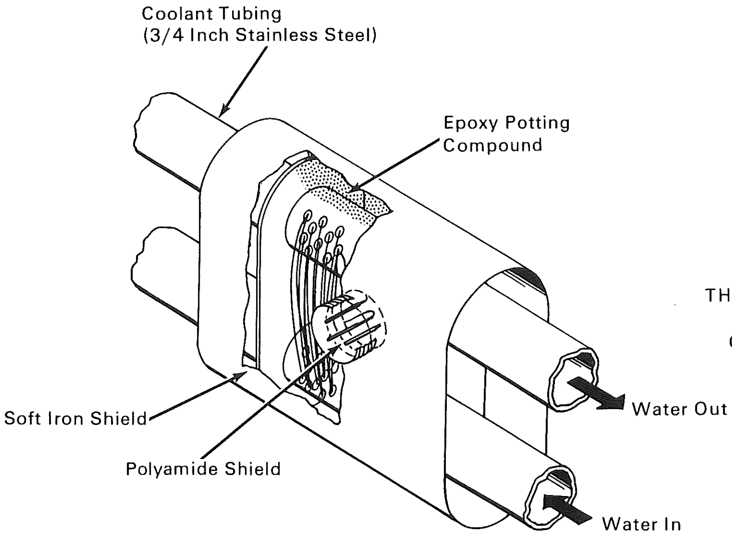
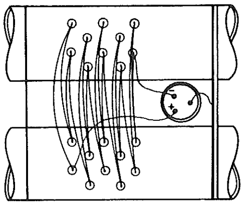
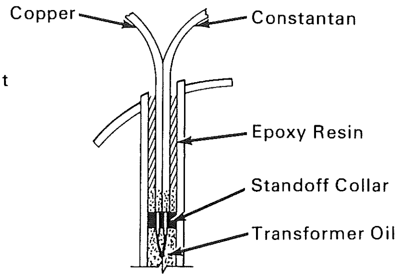
## Transducer Measures Temperature Differentials in Presence of Strong Electromagnetic Fields





ARRANGEMENT OF THERMOCOUPLE JUNCTIONS



DETAIL OF JUNCTION

**The problem:** Accurately measuring the temperature rise of cooling water at pressures exceeding 1000 psi in electric-arc heaters. A temperature transducer used in the environment of such heaters would have to be insensitive to multimegawatt electrical discharges emitting random-frequency radiation through a spectrum from 0 to 40 kc, voltages induced by neighboring magnetic fields, and stray electric currents in the cooling water. In addition, the instrument must respond rapidly to small differential temperatures and deliver a signal not requiring external amplification.

**The solution:** A magnetically shielded thermopile with interconnecting wires of small loop area to minimize electromagnetically induced voltages. The thermocouple junctions are immersed in an oil-filled well to isolate them from the stray electric currents in the cooling water.

**How it's done:** The transducer consists of a 20-junction thermopile mounted within a pair of large diameter (3/4-inch) stainless steel coolant tubes by means of 20 individual hypodermic tubing wells. The junctions are arranged so as to minimize the area of the loop formed by the interconnecting wire and thus minimize electromagnetically induced voltages. This arrangement also ensures adequate sampling of bulk stream temperatures of the water under turbulent flow conditions. The entire assembly is encapsulated in epoxy resin and encased in a soft-iron sheath which is electrically connected to the coolant tubes to form a complete magnetic shield around the thermopile. Ten

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"hot" junctions and ten "cold" junctions are connected in series to obtain a tenfold multiplication of the thermoelectric signal. Each junction is immersed in an oil-filled well to isolate it electrically from the water and hermetically sealed with an epoxy resin.

The output is taken from two terminals of a 3-pronged connector which is electrically isolated from the soft iron casing. The plug terminates one end of a length of 2-conductor shielded cable which carries the output signal to a current-sensitive galvanometer-type recorder. The electromagnetic shielding is made continuous by connecting the iron casing to the cable shielding via the third prong. The entire instrument measures approximately 6×3×1 1/2 inches.

## Notes:

1. This instrument would be useful for measuring temperature differentials of most coolant fluids subjected to strong electromagnetic fields and stray electric currents.
2. Further information concerning this invention is described in a paper entitled, *Measuring Temperature in Strong Fields*, by David Wald, in Instruments and Control Systems, V. 36, No. 5, May 1963. Inquiries may also be directed to:

   Technology Utilization Officer
   Ames Research Center
   Moffett Field, California, 94035
   Reference: B65-10089

**Patent status:** NASA encourages the immediate commercial use of this invention. It is owned by NASA, and a patent application has been filed. Royalty-free nonexclusive licenses for its commercial use are available. Inquiries concerning license rights should be made to NASA, Code AGP, Washington, D.C. 20546.

Source: Ames Research Center
(ARC-27)

April 1965

Brief 65-10093

# NASA TECH BRIEF

## Computer Programs Simplify Optical System Analysis

**The problem:** Modern optical systems frequently require the use of nonspherical reflecting and refracting elements (ellipsoids, paraboloids, hyperboloids, cones, cylinders). Design of these optical systems requires many complex time-consuming computations.

**The solution:** Computer programs which perform geometrical ray tracing and calculate energy distributions in optical systems containing nonspherical as well as spherical elements.

**How it's done:** Two digital computer programs have been formulated to aid in the design of complex optical systems. One program traces the path of a light ray through the optical system. The other calculates the energy output incident on specified target areas.

The optical ray-trace program calculates the path of a ray for which the initial coordinates and direction have been specified. This program is sufficiently general to cover arbitrary orientation of any of the elements for rays undergoing reflection or refraction at any portion of the optical surface. The output from the ray-trace program is the location and direction of the ray at the last optical surface in the system and the total optical path length of the ray.

The energy-trace program calculates the relative monochromatic flux density on a specified target area receiving radiation from a finite incoherent source. The program tabulates the flux densities and plots a monochromatic brightness distribution of the source as seen from the target area. The energy-trace program uses the optical ray-trace program as a subroutine to generate a representation of the optical system.

**Notes:**

1. The ray-tracing program can also be applied to optical elements that are not generated by revolution of a conic section.
2. Optical systems incorporating diffraction gratings may be analyzed without making major modifications in the logical structure of the computer program.
3. Inquiries concerning this innovation may be directed to:

   Technology Utilization Officer
   Goddard Space Flight Center
   Greenbelt, Maryland, 20771
   Reference: B65-10093

**Patent status:** NASA encourages commercial use of this innovation. No patent action is contemplated.

Source: Honeywell, Inc.
under contract to Goddard Space Flight Center
(GSFC-306)

Category No. 01

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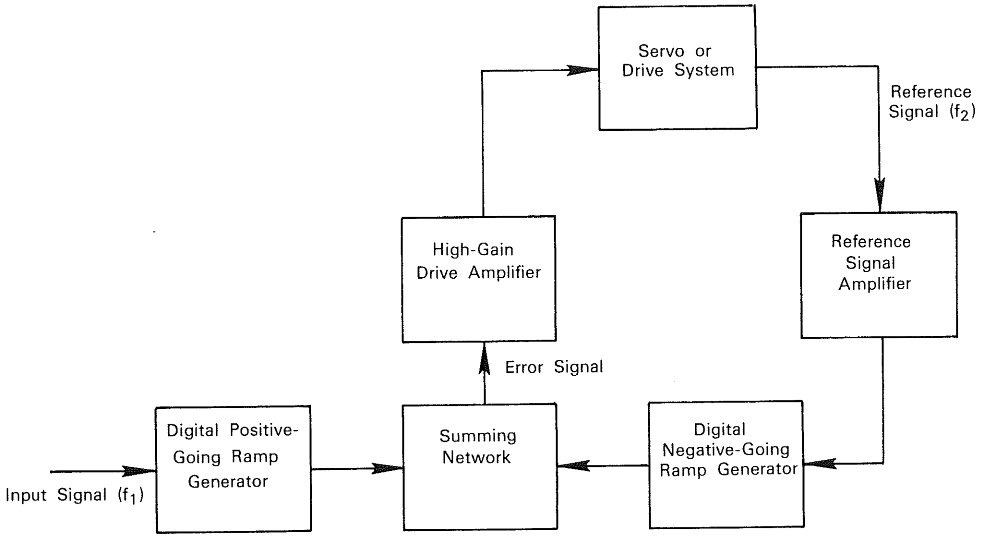
April 1965 Brief 65-10096

# NASA TECH BRIEF

## Digital System Accurately Controls Velocity of Electromechanical Drive


Servo or Drive System
Reference Signal (f2)
High-Gain Drive Amplifier
Reference Signal Amplifier
Error Signal
Digital Positive-Going Ramp Generator
Summing Network
Digital Negative-Going Ramp Generator
Input Signal (f1)

**The problem:** Accurately controlling the velocity of an electromechanical drive mechanism. An example of such a mechanism is the drive for the mirror in an interferometer-type spectrometer. Analog circuits which have been used to provide velocity control depend on the gain and phase characteristics of the circuit components. Environmental conditions and component aging tend to alter these characteristics and reduce the attainable control accuracy.

**The solution:** The use of a digital circuit, rather than an analog circuit, to control the velocity of the drive mechanism. Since the essential electronic components used in the digital circuit function only as switches (open or saturated), their gain and phase characteristics are relatively unimportant.

**How it's done:** The digital circuit consists of five basic units: a digital positive-going ramp generator, a digital negative-going ramp generator, a summing network, a high-gain drive amplifier, and a reference-signal amplifier. The input signal, at frequency $f_1$, is coupled to the digital positive-going ramp, which is coupled to the summing network. A reference signal at frequency $f_2$ proportional to the velocity of the mirror in the drive system is amplified and fed into the digital negative-going ramp. This reference signal, now in digital form, is also fed into the summing network. The addition of the signals in the summing network results in an error signal. This signal is amplified by the high-gain drive amplifier and used to keep the drive velocity and the reference signal constant.

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**Notes:**

1. The two ramp generators and the summing network may be incorporated into a single unit.
2. The control accuracy depends on the stability of the input signal frequency.
3. Inquiries concerning this invention may be directed to:

Technology Utilization Officer
Goddard Space Flight Center
Greenbelt, Maryland, 20771
Reference: B65-10096

**Patent status:** NASA encourages the immediate commercial use of this invention. Inquiries about obtaining rights for its commercial use may be made to NASA, Code AGP, Washington, D.C., 20546.

Source: Grady B. Nichols
(GSFC-287)

April 1965

Brief 65-10097

# NASA TECH BRIEF

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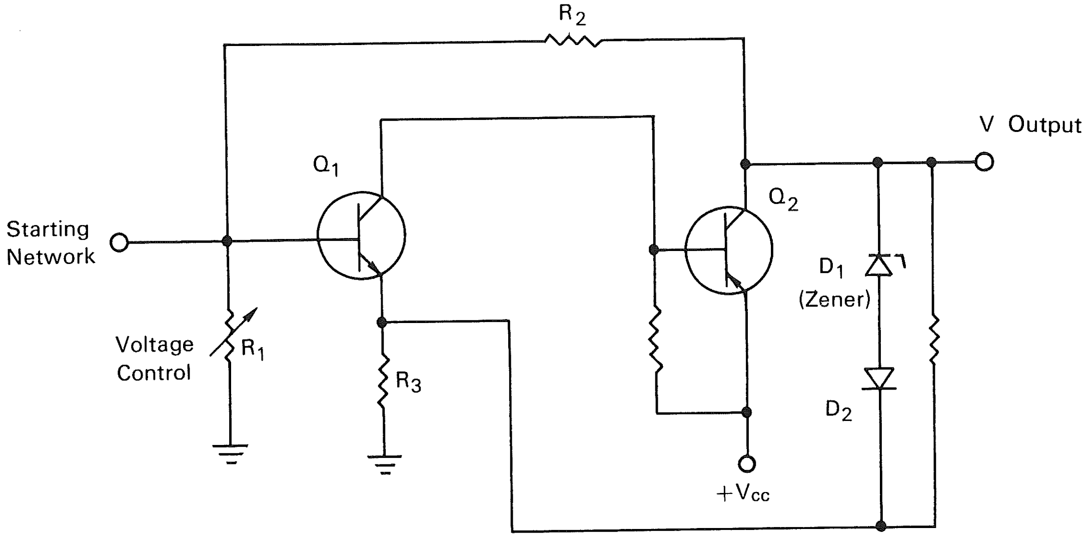
## Variable Voltage Supply Uses Zener Diode as Reference



**The problem:** Zener-diode regulated power supplies are used to provide accurate and stable reference voltages. These power supplies, however, are somewhat limited in their applications, since a zener diode can provide only a single reference voltage. More complex circuitry is required to provide a variable reference supply.

**The solution:** A simple transistorized circuit, using a zener diode as the reference element, to provide a stable variable reference voltage.

**How it's done:** As shown on the schematic diagram, zener diode $D_1$ is used as the reference element for the variable reference voltage supply. Voltage control is provided by a two-stage amplifier, consisting of transistors $Q_1$ and $Q_2$. The output voltage can be varied by adjusting resistor $R_2$, and is equal to

$$V_{out} = V_z(1 + \frac{R_1}{R_2})$$

where $V_z$ is the breakdown voltage of the zener diode.

A positive starting signal applied to the base of $Q_1$ is required to activate the supply. Since a positive feedback loop between the transistors is incorporated in the circuit, the starting signal can be removed when the zener diode starts to conduct.

Current flow through $Q_1$ and $Q_2$ is controlled by the setting of $R_1$. Increasing the resistance of $R_1$ increases the current flow through the transistors which, in turn, cause an increased current flow through zener diode $D_1$and resistor $R_3$. The output voltage appears across the series connection of $D_1$ and $R_3$. As the characteristics of the zener diode are fixed, an increased output voltage can be obtained by increasing the voltage (IR drop) across $R_3$. The voltage rise at

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the emitter of $Q_1$ limits the positive feedback in the circuit and prevents unlimited increase of the output voltage.

## Notes:

1. Diode $D_2$ is included in the circuit to eliminate output voltage dependence upon the emitter-base voltage of $Q_1$. It may be omitted from the circuit, if desired.
2. The output voltage may be applied to an emitter follower circuit to obtain higher operating currents.
3. This innovation should be of interest to manufacturers of low-voltage power supplies and to researchers in need of variable voltage reference supplies.
4. Inquiries concerning this innovation may be directed to:

    Technology Utilization Officer
    Goddard Space Flight Center
    Greenbelt, Maryland, 20771
    Reference: B65-10097

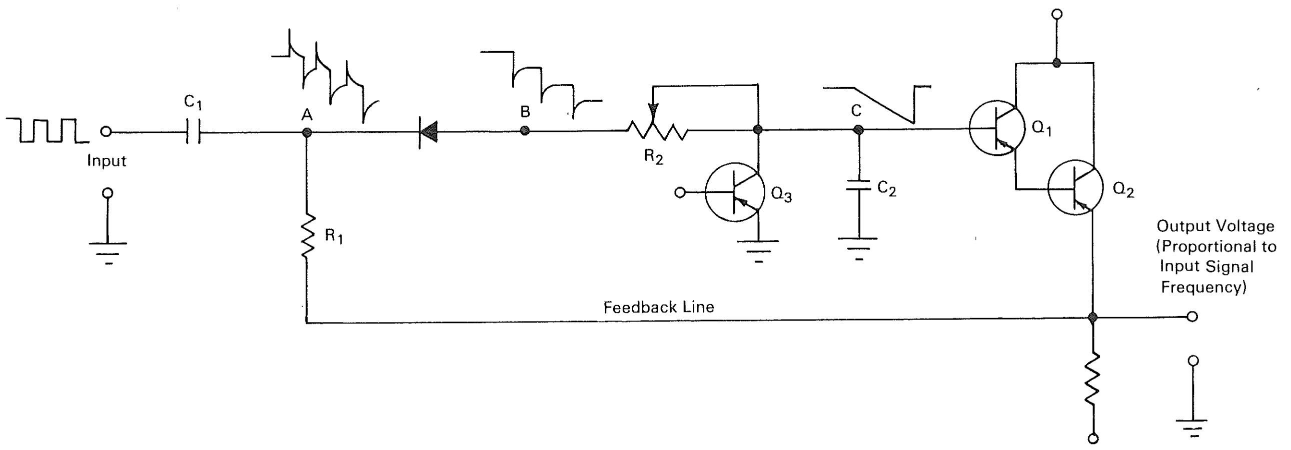
**Patent status:** NASA encourages commercial use of this innovation. No patent action is contemplated.

Source: R. C. Lavigne and L. L. Kleinberg
(GSFC-262)

April 1965 Brief 65-10102

# NASA TECH BRIEF

## Simple Circuit Functions as Frequency Discriminator for PFM Signals



**The problem:** To monitor the frequency of PFM (pulse frequency modulated) telemetry signals. The frequency discriminator to be used for this purpose must be less complex than conventional discriminators or frequency counters.

**The solution:** A simple circuit whose output voltage is directly proportional to the input frequency and which provides a means for rapidly sampling particular frequency channels.

**How it's done:** The discriminator consists of four simple branches: a differentiator ($C_1$, $R_1$), a variable time-constant integrator ($R_2$, $C_2$), a transistor dump switch ($Q_3$), and a Darlington-type common-collector transistor amplifier ($Q_1$, $Q_2$).

The PFM signal is shaped by a one-shot multivibrator (not illustrated) to produce square wave pulses of constant pulse width and at a repetition rate equal to the frequency of the PFM signal. These square wave pulses are applied to the discriminator input. The differential waveform shown at point A, appears as negative going pulses at point B. The variable time-constant integrator averages these pulses into a single negative-going spike at point C. Transistors $Q_1$ and $Q_2$ offer a high impedance to $C_2$ and thereby prevent its discharge. The potential on the emitter of $Q_2$ follows the potential of $C_2$ during charging of this capacitor. The feedback line from the common-collector amplifier provides a reference voltage for $R_1$. As the feedback line becomes more negative, the reference voltage and point A also become more negative, with the result that the voltage across $R_2$ is always at the voltage amplitude of the incoming pulse. During integration, therefore, a constant current is supplied to $C_2$, charging it at a linear rate. Transistor $Q_3$ acts as a dumping switch which can be controlled to maintain $C_2$ in an uncharged condition until the channel to be sampled is selected.

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**Notes:**

1. The output of the discriminator can be applied to a strip chart recording oscillograph for permanent recording of the sampled frequencies.

2. The discriminator should be useful as a constant-current integrator for various applications, such as in linear sweep circuits and time delay circuits.

3. Inquiries concerning this innovation may be directed to:

   Technology Utilization Officer
   Goddard Space Flight Center
   Greenbelt, Maryland, 20771
   Reference: B65-10102

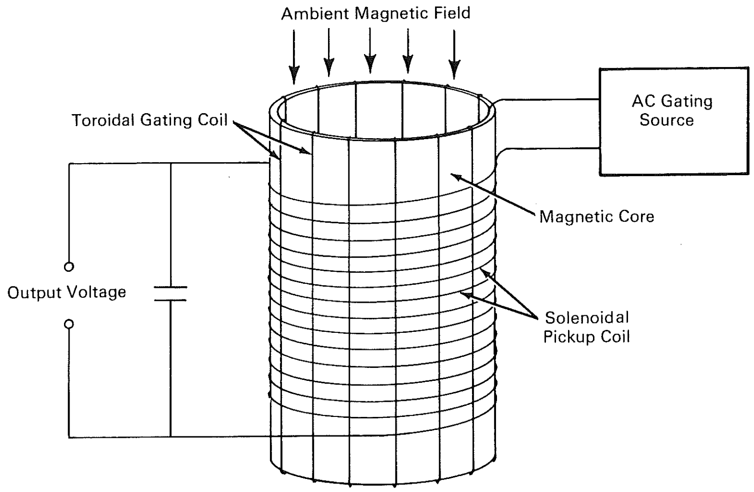
**Patent status:** NASA encourages commercial use of this innovation. No patent action is contemplated.

Source: James Billingsley
(GSFC-267)

April 1965 Brief 65-10103

# NASA TECH BRIEF

## Improved Magnetometer Uses Toroidal Gating Coil



**The problem:** Providing a magnetometer with improved accuracy and sensitivity. Interaction of the magnetic flux produced by the magnetometer gating source with the ambient magnetic field (e.g., the earth's magnetic field) being measured by the magnetometer can introduce noise or error in the pickup coil (unless very careful filtering is provided), resulting in an inaccurate measurement. Gating flux leakage may also disturb the ambient field sufficiently to introduce error in other nearby magnetometers or electronic circuits.

**The solution:** A magnetometer employing a cylindrical, high-permeability magnetic core, with a toroidal gating coil winding and a solenoidal pickup coil winding.

**How it's done:** The toroidal gating coil is uniformly wound so that each turn is parallel to the longitudinal axis of the magnetic core. With this manner of winding, the effective direction of the magnetic flux generated by the current in the gating coil will be perpendicular to the core axis, thereby minimizing axial flux leakage and disturbance of the ambient magnetic field. Since the toroidal winding completely surrounds the magnetic core, the gating flux constitutes a circular magnetizing field that is effectively confined to the core. The solenoidal pickup coil is comprised of a relatively large number of turns which are uniformly wound so as to be concentric with the axis of the core. Gating flux is thus effectively decoupled from the pickup coil windings, both because of the relative perpendicularity of the toroidal and pickup coil windings and the confinement of the gating flux in the core. Both sets of windings are electrically insulated from the core.

In making a measurement, the core is positioned so that its axis is parallel to the ambient magnetic field. The ac gating current generates an alternating magnetic field which cyclically desaturates and saturates

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the magnetic core, thereby varying its permeability from its original high value to unity. Since saturation and desaturation occur twice for every cycle of gating current, the ambient magnetic flux within the core and the resultant output voltage from the toroidal coil cycle at twice the frequency of the gating current. The capacitor across the solenoidal coil makes the pickup circuit parallel-resonant at the output voltage frequency. The output voltage is proportional to the rate of change of the gated ambient flux. A calibrated voltmeter connected to the output leads indicates the magnitude of the ambient magnetic field.

**Notes:**

1. Flux interaction can be further reduced by electrostatically shielding the pickup coil from the gating coil.
2. An early model of this magnetometer had a sensitivity approximately one hundred times that of standard flux gate magnetometers of comparable physical size.
3. The magnetometer may be used as a magnetic amplifier for low-level electrical signals which have been converted to low-level magnetic fields.
4. The principle of this magnetometer should have application in navigation devices.
5. Inquiries concerning this invention may be directed to:

Technology Utilization Officer
Goddard Space Flight Center
Greenbelt, Maryland, 20771
Reference: B65-10103

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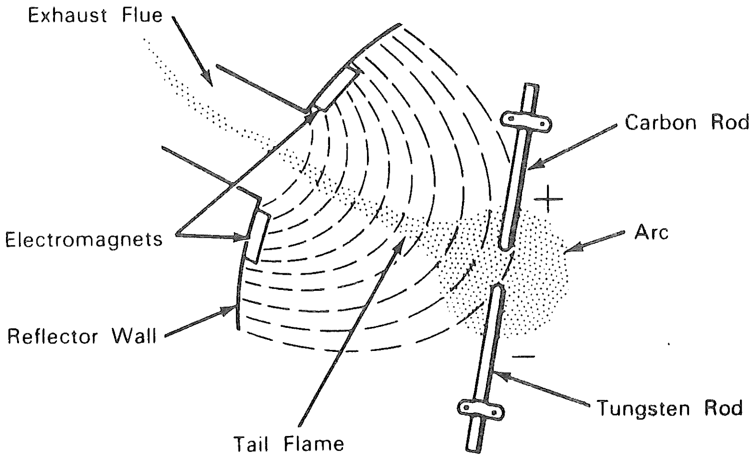
Source: Cornell University
under contract to Goddard Space Flight Center
(GSFC-249)

April 1965 Brief 65-10108

# NASA TECH BRIEF

## Magnetic Field Controls Carbon Arc Tail Flame



**The problem:** During normal operation of carbon-arc devices, there is a heavy electron flow approaching 400 amperes from the tungsten negative to the carbon positive. The tail flame resulting from this arc must be removed by an exhaust flue. The high arc current creates a magnetic field that exerts a force on the positively charged tail flame. This has a tendency to divert the tail flame away from the exhaust flue, thus causing adjacent contamination.

**The solution:** A pair of matched, variable electromagnets, placed on either side of and adjacent to the exhaust flue. The polarity of these electromagnets is so arranged that they produce a magnetic field opposite in orientation to that produced by the carbon arc. This effectively cancels out the arc field and the tail flame is drawn to the exhaust flue by its air-driven suction.

**How it's done:** The electromagnets placed on each side of the exhaust flue produce a curved magnetic field, whose lower segment intrudes and cancels the field produced by the arc. Since the flue has a fan-driven constant air suction, the tail flame with its products of combustion is drawn into the flue in the absence of an intervening force. In operation, the curved shape of the imposed magnetic field acts as a force component to direct the tail flame toward the center of the flue. Flexibility in this corrective device is inherent since the imposed magnetic field is readily adjusted to meet any change in the arc current component.

**Notes:**

1. Since the arc is started by ionization breakdown through a high voltage "kick" the electromagnetic field should not be imposed until running current occurs or the necessary starting ionization will not take place.
2. This device should appreciably reduce maintenance cycles on theater projectors, arc lamp spotlights, carbon-arc furnaces, and any arc-powered illumination devices.

(continued overleaf)

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3. Inquiries concerning this innovation may be directed to:

   Technology Utilization Officer
   Manned Spacecraft Center
   P.O. Box 1537
   Houston, Texas, 77001
   Reference: B65-10108

**Patent status**: NASA encourages commercial use of this innovation. No patent action is contemplated.

Source: Radio Corporation of America
under contract to Manned Spacecraft Center
(MSC-139)

SMALL BUSINESS ADMINISTRATION
506 Second Avenue
Seattle, Washington 98104
K. L. McBreen, Indust. Spec.

April 1965

Brief 65-10111

# NASA TECH BRIEF

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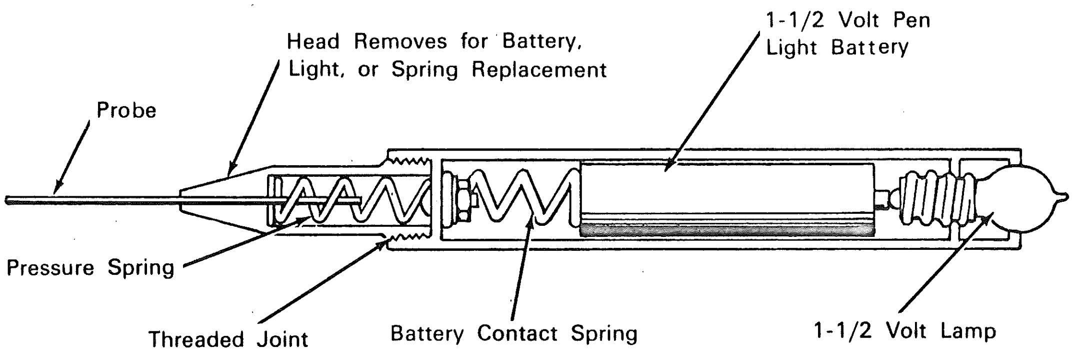
## Probe Tests Microweld Strength


Head Removes for Battery, Light, or Spring Replacement
1-1/2 Volt Pen Light Battery
Probe
Pressure Spring
Threaded Joint
Battery Contact Spring
1-1/2 Volt Lamp

**The problem:** Inspection of microwelds is necessary because of the problems of material variation, human error, and process control inherent in microwelding techniques. However, visual inspection alone is not reliable.

**The solution:** A pressure-adjustable spring-loaded probe to test soldered, brazed, or microwelded joints. The probe is more reliable than mere visual inspection since any desired test pressure may be applied to the joint.

**How it's done:** The spring-loaded probe may be adjusted to the desired test pressure by means of a threaded probe head. As pressure is applied to the weld, the probe is forced into the probe housing, thus depressing the spring. When the desired pressure has been applied to the weld, the probe makes contact with a 1-1/2-volt penlight battery causing a 1-1/2-volt indicator lamp to be lighted. Visual inspection will determine whether or not the weld was able to withstand the test pressure.

**Notes:**

1. The battery spring acts as an overtravel spring in case the test probe overtravels after the indicator lamp has been lighted.
2. This device should find use in the electronics industry for the reliable testing of soldered, brazed, or microwelded joints.
3. Inquiries concerning this innovation may be directed to:

   Technology Utilization Officer
   Western Operations Office
   150 Pico Boulevard
   Santa Monica, California, 90406
   Reference: B65-10111

**Patent status:** NASA encourages commercial use of this innovation. No patent action is contemplated.

Source: Douglas Aircraft Company, Inc.
under contract to Western Operations Office
(WOO-118)

Category No. 05

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April 1965

Brief 65-10112

NASA TECH BRIEF

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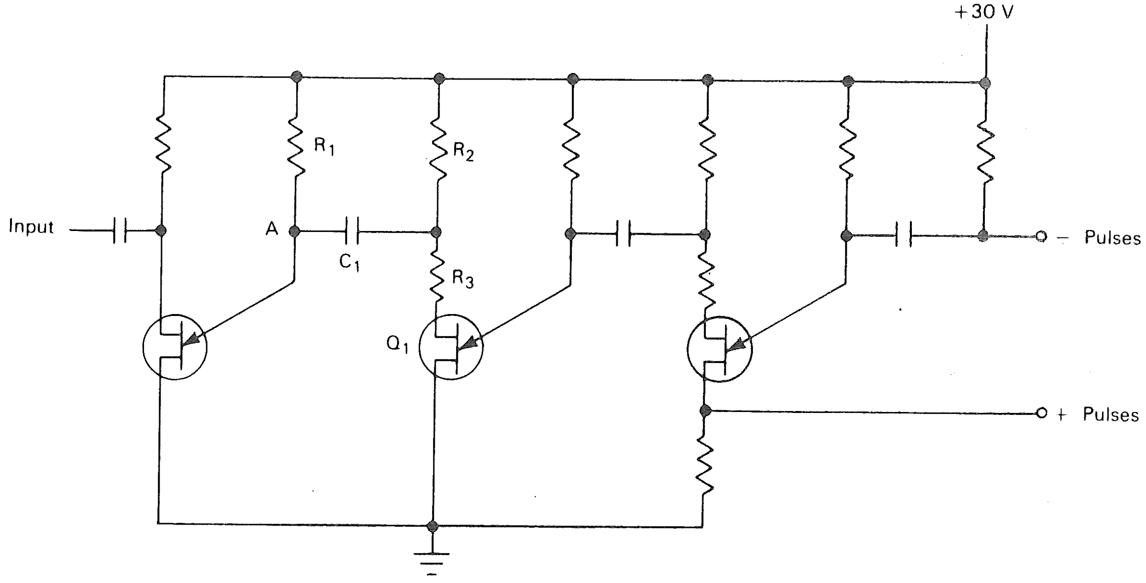
# Unijunction Frequency Divider Is Free of Backward Loading



**The problem:** Present unijunction frequency dividers have a tendency toward loading in the backward direction. This causes undesirable triggering of preceding stages.

**The solution:** A simple frequency divider using unijunction transistors has few elements per stage and reduces backward loading to a minimum.

**How it's done:** Each stage in the frequency divider is a relaxation oscillator. The capacitor $C_1$ quickly charges through $R_2$ and slowly discharges through $R_1$ and $R_2$. The charging current through $R_2$ lowers the voltage at point A and may cause the next stage to fire. However, the larger value of $R_3$ keeps the current through the base of $Q_1$ low so that the size of the pulse generated in $R_2$ is kept so low that one stage will not trigger a preceding stage. Thus the circuit reduces loading of each stage by feeding each output into a low impedance loop. At the same time, backward loading is reduced since the synchronization signal of each stage is picked up by a high impedance loop in the following stage. This high impedance loop results in low currents which do not create appreciable sync voltages in the preceding stage.

**Notes:**

1. Circuits of this design should find application in timing devices and in sync generators for television systems.

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2. Inquiries concerning this innovation may be directed to:

   Technology Utilization Officer
   Jet Propulsion Laboratory
   4800 Oak Grove Drive
   Pasadena, California, 91103
   Reference: B65-10112

**Patent status**: NASA encourages commercial use of this innovation. No patent action is contemplated.

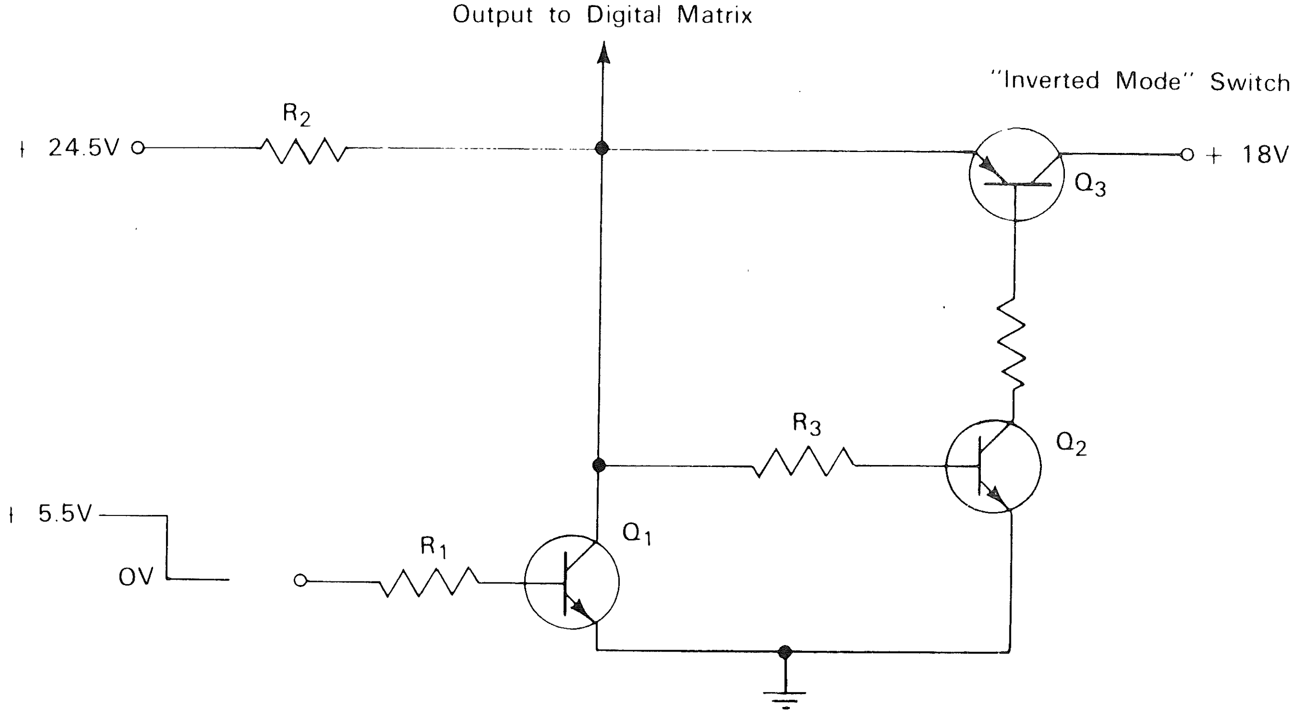
Source: Avard F. Fairbanks
(JPL-WOO-010)

April 1965

Brief 65-10118

# NASA TECH BRIEF

## Transistorized Circuit Clamps Voltage With 0.1% Error



**The problem:** To apply two accurately clamped voltage levels (+18 or 0 volts) to the input of a digital-to-analog resistive matrix that binarily develops a deflection staircase.

**The solution:** A transistorized clamping circuit that clamps either of two voltage levels (+18 or 0 volts) with less than 0.1 percent voltage offset.

**How it's done:** When a positive 5.5-volt level is applied to the base of transistor $Q_1$ through resistor $R_1$, transistor $Q_1$ is driven into saturation. In this state, the collector-emitter voltage of transistor $Q_1$ is approximately 30 millivolts and is relatively independent of temperature. The output of transistor $Q_1$ is applied directly to the digital matrix and to the base of transistor $Q_2$ through resistor $R_3$. This holds transistor $Q_2$ at cutoff, which in turn keeps transistor $Q_3$ (operating as an "inverted-mode" switch) biased off.

When a zero-volt level is applied to the base of transistor $Q_1$ through resistor $R_1$, transistor $Q_1$ is biased off. Transistor $Q_2$ is driven into saturation by current from the 24.5-volt supply through resistors $R_2$ and $R_3$. The output of transistor $Q_2$ turns transistor

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$Q_3$ on and allows the 18-volt supply to be applied through transistor $Q_3$ to the digital matrix. The collector-emitter voltage in transistor $Q_3$ is approximately 5 millivolts.

**Notes:**

1. Whereas ideal output levels are 18.0 volts and 0.0 volt, actual performance obtainable is 18.005 volts ±5 mv, and 0.030 volt ±15 mv.
2. Although the speed of operation of this clamping circuit technique is limited by the charge storage in transistor $Q_1$, it may be useful for analog, digital, and hybrid circuit applications.
3. Inquiries concerning this invention may be directed to:

   Technology Utilization Officer
   Goddard Space Flight Center
   Greenbelt, Maryland, 20771
   Reference: B65-10118

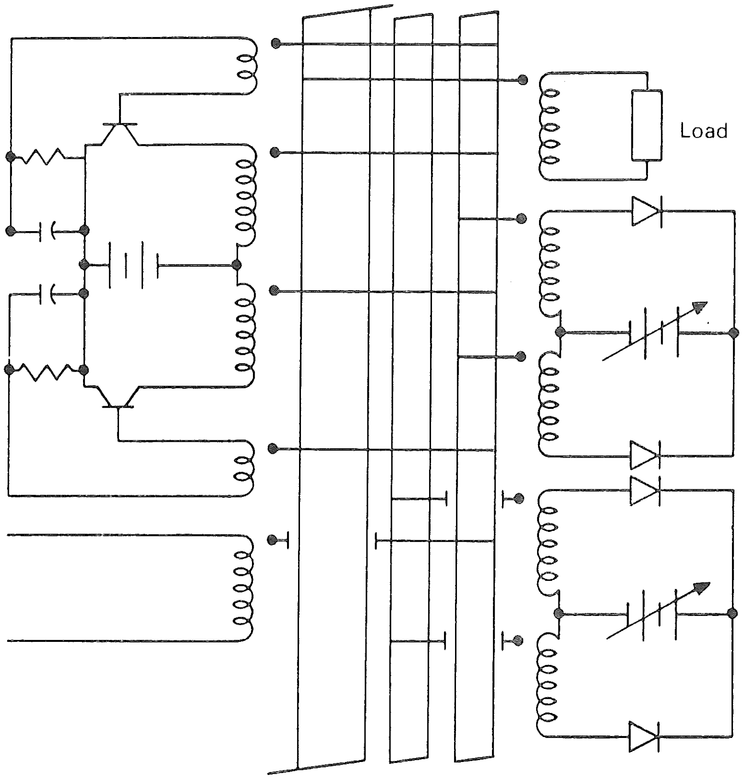
**Patent status:** NASA encourages the immediate commercial use of this invention. Inquiries about obtaining rights for its commercial use may be made to NASA, Code AGP, Washington, D.C., 20546.

Source: Radio Corporation of America,
under contract to Goddard Space Flight Center
(GSFC-196)

April 1965 Brief 65-10119

# NASA TECH BRIEF

## Variable Frequency Transistor Inverters Use Multiple Core Transformers



**The problem**: To design a class of magnetic-coupled multivibrators which will provide frequency control and other operational characteristics not easily obtained with conventional magnetic-coupled multivibrators.

**The solution**: Use two or more square-loop cores with multiple windings in a single transformer package.

**How it's done**: The transformer package consists of a saturable transformer containing a main square-loop core and an auxiliary or control square-loop core. The rate at which the main core swings from one saturation level to another is the transformer output frequency. The auxiliary core is arranged so that within certain limits, it can either increase or decrease the swing rate of the main core, thereby indirectly controlling the transformer output frequency. Externally, a variable dc control voltage is applied to the auxiliary core winding and a switching circuit is connected to the input of the transformer. The switching circuit is arranged so that each time the main core saturates, the input voltage to the transformer reverses

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polarity. Under these conditions, the instant the main core saturates, the input voltage immediately attempts to saturate it in the opposite direction. However, the time required for the main core to react is determined by the level of the dc voltage applied to the auxiliary core. Thus, the output frequency of the transformer is determined by the magnitude of the control voltage. The following operational characteristics have been obtained through various arrangements of cores and external circuits:

1. Output frequency decreasing with increasing control voltage.
2. Output frequency increasing with increasing control voltage.
3. Output frequency as a function of sum of control voltages.

**Notes:**

1. The characteristics obtainable by this innovation may be advantageous in a variety of applications:
   a. Power oscillators in which the output frequency must be controlled electrically as part of certain feedback control systems.
   b. Nonlinear magnetic circuitry requiring a constant frequency source of ac voltage.
   c. Telemetry circuits requiring voltage-to-frequency transducers.
2. Inquiries concerning this innovation may be directed to:

   Technology Utilization Officer
   Goddard Space Flight Center
   Greenbelt, Maryland, 20771
   Reference: B65-10119

**Patent status:** NASA encourages commercial use of this innovation. No patent action is contemplated.

Source: Duke University,
under contract to Goddard Space Flight Center
(GSFC-183)

April 1965

Brief 65-10120

# NASA TECH BRIEF

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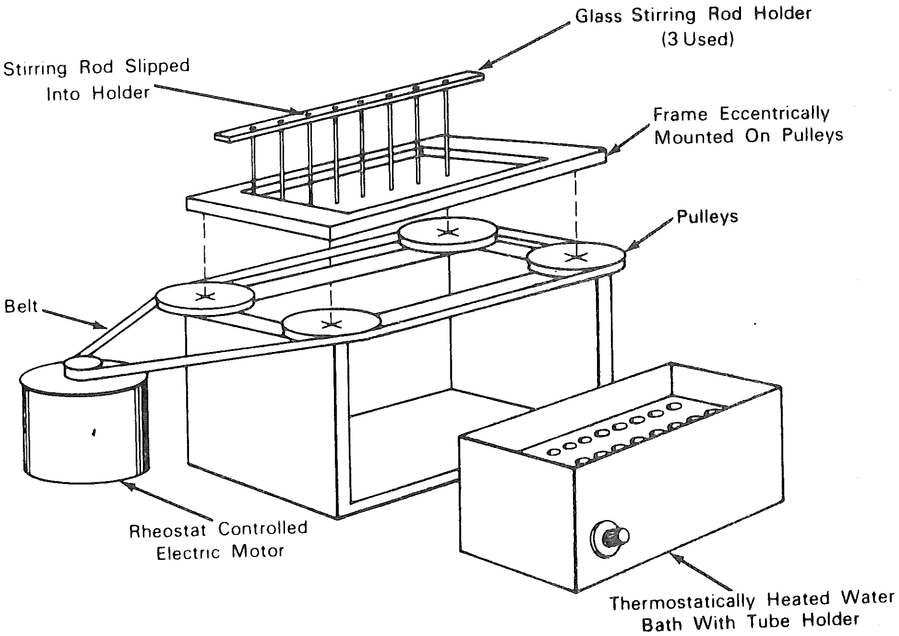
## Multiple Test Tubes Stirred Mechanically


Glass Stirring Rod Holder (3 Used)
Stirring Rod Slipped Into Holder
Frame Eccentrically Mounted On Pulleys
Pulleys
Belt
Rheostat Controlled Electric Motor
Thermostatically Heated Water Bath With Tube Holder

**The problem:** To stir the contents of many test tubes simultaneously under precisely controlled laboratory conditions.

**The solution:** A mechanical stirring device which accommodates up to 25 test tubes incorporating the following features: variable stirring rate; minimal exposure of tube contents to contamination; unattended operation over a period of up to 24 hours; thermal control of tube contents; and simple operation, cleaning, and maintenance. In addition, the device is able to stir solids which are in suspension.

**How it's done:** An electric motor is mounted on a framework which houses a water bath. Glass stirring rods are slipped into each of three stirring rod holders. These holders are then attached to an assembly which is eccentrically mounted on four pulleys that are driven by a belt from the drive motor. The eccentric motion of this upper frame causes the stirring rods to describe a circular motion in the test tubes. The test tubes are contained within a water bath which is supplied with a heater and thermostat.

A rheostat controlled electric motor allows a variable stirring rate and unlimited periods of operation. Construction is simple, thereby facilitating operation, cleaning, and maintenance. Temperature may be regulated by the thermostatically controlled water bath. The danger of contamination can be minimized by enclosing the device or using it in a controlled environment chamber.

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**Notes:**

1. This device should be useful in chemistry, biology, and medical laboratories which deal in large numbers of samples (e.g., hospital and testing and analytical laboratories).
2. Inquiries concerning this invention may be directed to:

   Technology Utilization Officer
   Ames Research Center
   Moffett Field, California, 94035
   Reference: B65-10120

**Patent status:** NASA encourages the immediate commercial use of this invention. Inquiries about obtaining rights for its commercial use may be made to NASA, Code AGP, Washington, D.C., 20546.

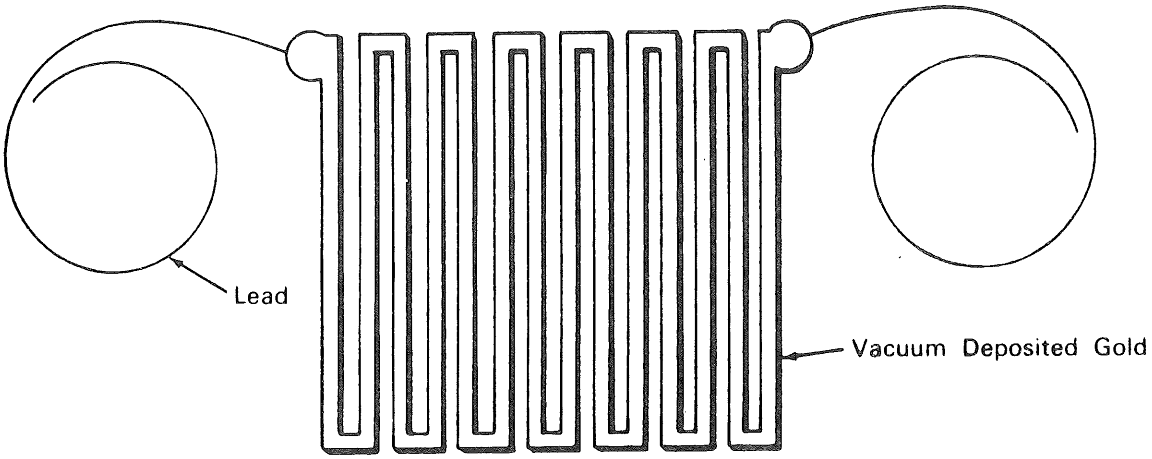
Source: Henry J. Leon and Ira J. Strong
(ARC-42)

April 1965

Brief 65-10123

# NASA TECH BRIEF

## Efficient Thin Film Heating Element Takes Minimum Space



**The problem:** Conventional elements for supplying small amounts of heat are somewhat bulky and have poor conductivity, requiring appreciable power inputs.

**The solution:** A light duty, thin-film heating element which is formed by vacuum deposition of metal onto a nonconductive surface to be heated.

**How it's done:** The evaporated metal heating element can be applied to thin plastic films such as polyethylene, glass, or metals having a polished surface. The shape of the heater depends on the resistance desired and the configuration required. A mask is prepared for depositing the metal to obtain the desired resistance and pattern. Terminals can be connected in various ways. If polyethylene is used, wires can be embedded in it and the film heating element can be evaporated over them, establishing contact.

**Notes:**

1. When the film heating element is applied on metals, anodizing or vapor coating is necessary to provide an insulating separator.
2. Materials such as paint or evaporated coatings, may be applied over the heater unit.
3. Vacuum deposited gold and nickel have both been used successfully as resistive elements.
4. Compared to conventional heating elements, this innovation has a much thinner structure and a much faster response time. It can be formed easier into a desired shape, can be used in very small areas, and can withstand limited flexure.
5. This idea may be of interest to manufacturers of heating elements, crystals, ovens, and packaged oscillators.

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6. Inquiries concerning this innovation may be directed to:

Technology Utilization Officer
Goddard Space Flight Center
Greenbelt, Maryland, 20771
Reference: B65-10123

**Patent status:** NASA encourages commercial use of this innovation. No patent action is contemplated.

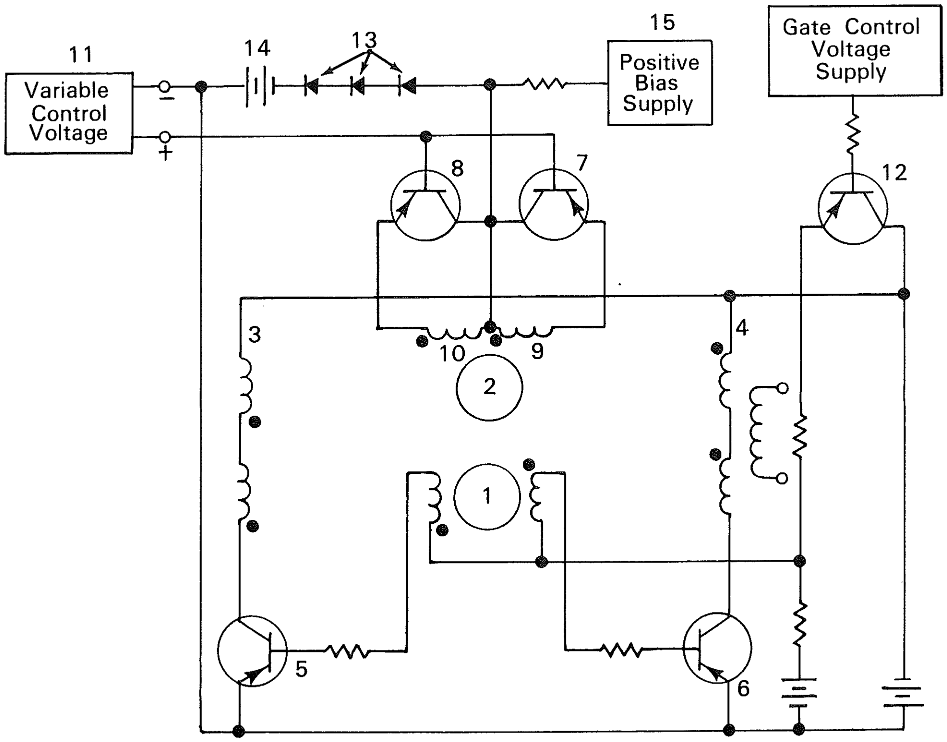
Source: Albert H. Busch
(GSFC-289)

May 1965

Brief 65-10124

# NASA TECH BRIEF

## Variable Frequency Magnetic Multivibrator Generates Stable Square-Wave Output



**The problem:** To design a variable frequency magnetic multivibrator which provides a stable square wave output over wide variations in temperature and in change of power supply potential.

**The solution:** A frequency control circuit which operates in a full wave fashion rather than only over a portion of the multivibrator cycle of operation; this results in greater stability of operation in the low end of the multivibrator operating frequency, and in rejection of undesirable high frequency modes.

**How it's done:** The multivibrator includes an uncontrolled magnetic core (1) and a controlled magnetic core (2). A pair of conductive loops (3) and (4), each consisting of drive windings for cores (1) and (2) and one of the controlled transistor switches (5) and (6), provide the necessary alternate mode of operation for the multivibrator. The frequency of the multivibrator is controlled by a circuit which consists of a full wave voltage limiter arrangement of transistors (7) and (8) and windings (9) and (10). The operation of the voltage limiter is controlled by the level of the

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variable control voltage (11). Changes in magnitude of this variable control voltage change the operating frequency of the multivibrator. Also included is an electronic gate (12) for starting and stopping the multivibrator, and a temperature compensation circuit consisting of thermal elements (13), a fixed bias potential (14), and a positive bias supply (15).

## Notes:

1. This invention may find application in devices using or concerning clocks, synchronous motor control, stable square wave variable signal generators, test instruments, power generation control, matching magnetic bearing devices, and radio and television communications.
2. Inquiries concerning this invention may be directed to:

Technology Utilization Officer
Goddard Space Flight Center
Greenbelt, Maryland, 20771
Reference: B65-10124

**Patent status:** NASA encourages the immediate commercial use of this invention. It is owned by NASA, and a patent application has been filed. Royalty-free nonexclusive licenses for its commercial use are available. Inquiries concerning license rights should be made to NASA, Code AGP, Washington, D.C., 20546.

Source: Steven Paull
(GSFC-AE-21)

May 1965

Brief 65-10125

# NASA TECH BRIEF

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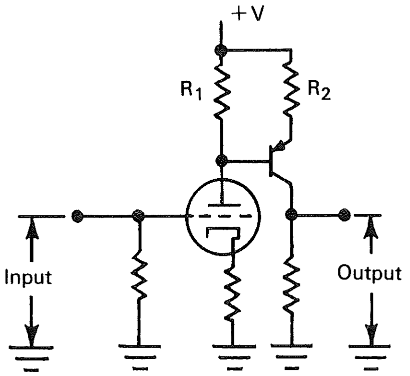
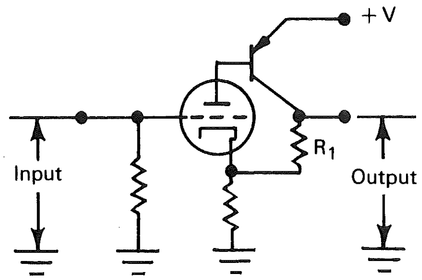
## Simplified Electrometer Has Excellent Operating Characteristics



OLD CIRCUIT



IMPROVED CIRCUIT

**The problem:** Previous electrometer circuits lacked simplicity and stability of gain and operating point. They had relatively low input impedance, were somewhat nonlinear in response, and required considerable power.

**The solution:** A circuit that possesses the following characteristics: simplicity, stability of gain and operating point, high-input impedance, linear response, and low power requirements.

**How it's done:** The operating characteristics are improved by modifying the circuit as shown. The previous circuit has a load resistor, $R_1$, in the plate circuit of the electrometer tube, and a resistor (bias), $R_2$, in the emitter of the input transistor. The effect of both of these resistors is to reduce the open loop gain of the circuit and to increase the power requirements.

In the improved circuit, the amplifier input transistor base-emitter junction is used as the plate load of the electrometer tube and the collector of the transistor is connected to the following amplifier stage and to a feedback circuit including resistor $R_1$. This feedback greatly improves the linearity of the electrometer over its operating range and improves the operating point stability and input impedance. With the improved circuit, no source current is wasted in a plate load resistor and no degeneration occurs due to the emitter bias circuit paralleling the plate load.

**Notes:**

1. This device should be useful in electrometer applications and in general high-input impedance applications. It would also be useful in instances where linearity and stability are required.

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2. Inquiries concerning this invention may be directed to:

Technology Utilization Officer
Jet Propulsion Laboratory
4800 Oak Grove Drive
Pasadena, California, 91103
Reference: B65-10125

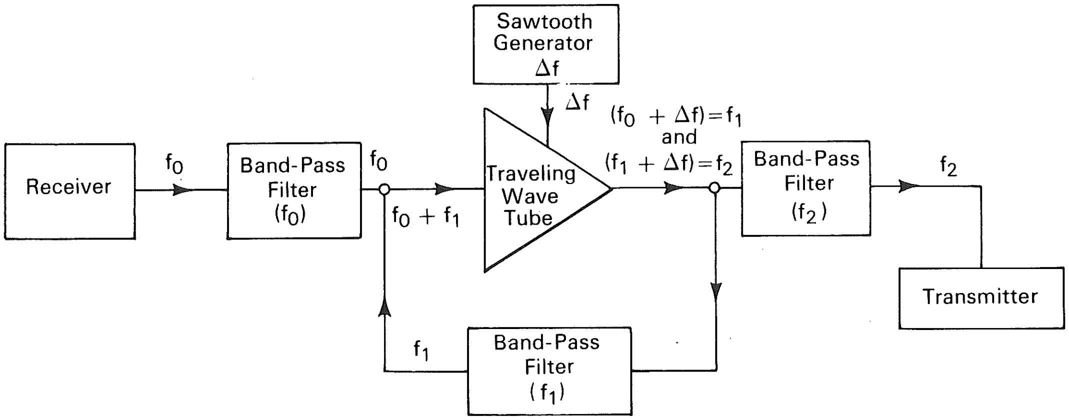
**Patent status**: NASA encourages the immediate commercial use of this invention. Inquiries about obtaining rights for its commercial use may be made to NASA, Code AGP, Washington, D.C., 20546.

Source: Roy E. Brantner
(JPL-413)

May 1965 Brief 65-10127

# NASA TECH BRIEF

## Traveling-Wave Tube Circuit Simplifies Microwave Relay



**The problem:** Long-distance microwave communication systems generally require signal amplification at active-repeater relay stations along the transmission path. To prevent feedback oscillations in the relay amplifier, the incoming microwave signal must be converted to a different microwave frequency for transmission. This conversion, usually accomplished by converting the incoming signal to an intermediate frequency which is then amplified and converted to a new microwave signal, has required a fairly complex system, consisting of a preselector, mixers, a local oscillator, amplifiers, and filters.

**The solution:** A circuit employing a sawtooth-modulated traveling-wave tube, which serves both as a frequency converter and as an amplifier.

**How it's done:** The microwave input signal at frequency $f_0$ is coupled by an $f_0$ band-pass filter to the sawtooth-modulated (frequency Δf) traveling-wave tube, where transit-time modulation of the signal takes place. When the slope of the sawtooth modulating signal is positive, the output from the traveling-wave tube comprises signals of frequency $f_1$ (equal to $f_0 + \Delta f$) and $f_2$ (equal to $f_1 + \Delta f$), respectively. These signals are coupled to two band-pass filters tuned to frequency $f_1$ and $f_2$, respectively. The output from the $f_1$ band-pass filter is coupled back to the input of the traveling-wave tube. The output from the $f_2$ band-pass filter is then a twice-amplified microwave signal at frequency $f_2$, which is transmitted by the system.

**Notes:**

1. Lower power losses and reduced size and weight are realized in this circuit, because it eliminates separate rf mixers and uses fewer filters than required in previous designs.
2. Inquiries concerning this invention may be directed to:

   Technology Utilization Officer
   Goddard Space Flight Center
   Greenbelt, Maryland, 20771
   Reference: B65-10127

(continued overleaf)

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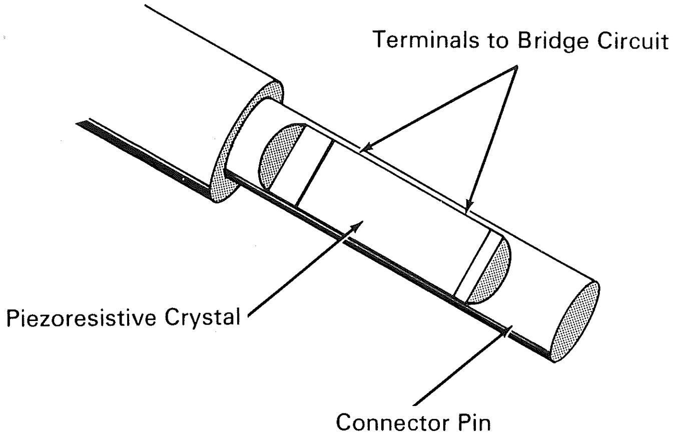
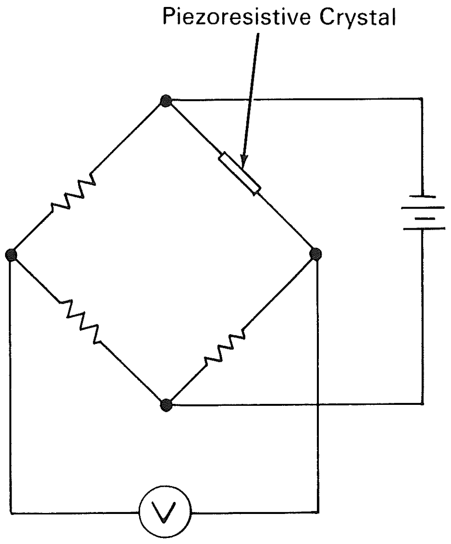
Source: W. K. Allen, L. J. Ippolito and D. A. Nace
(GSFC-299)

May 1965 Brief 65-10128

# NASA TECH BRIEF

## Piezoresistive Gage Tests Pin-Connector Sockets





**The problem:** Inspection testing of the electrical contact characteristics of pin-connector sockets that employ retainer springs or snaps to exert contact force on the mating pins. The spring must exert sufficient force to ensure proper electrical contact between socket and pin.

**The solution:** A test method using a test pin (the same size as a connector pin) on which a piezoresistive semiconductor (e.g., silicon) crystal is rigidly mounted and connected as one leg of a bridge circuit.

**How it's done:** The piezoresistive crystal is rigidly mounted in a recess on the test pin. When the pin is inserted into a socket to be tested, the force exerted by the retainer spring causes the pin and crystal to deflect slightly. The change in the resistance of the crystal due to the deflection is directly proportional to the force exerted by the retainer spring. A voltmeter in the bridge circuit is calibrated to give a direct reading of this force. For inspection testing, a lower tolerance limit is marked on the voltmeter face to indicate acceptance or rejection of the sockets.

**Notes:**

1. This testing method can be applied to a multiple-connector socket by using a connector with multiple test pins. The outputs of the pins would be fed into a programed sequencing switch for automatic acceptance or rejection of the socket.
2. Inquiries concerning this invention may be directed to:

   Technology Utilization Officer
   Jet Propulsion Laboratory
   4800 Oak Grove Drive
   Pasadena, California, 91103
   Reference: B65-10128

(continued overleaf)

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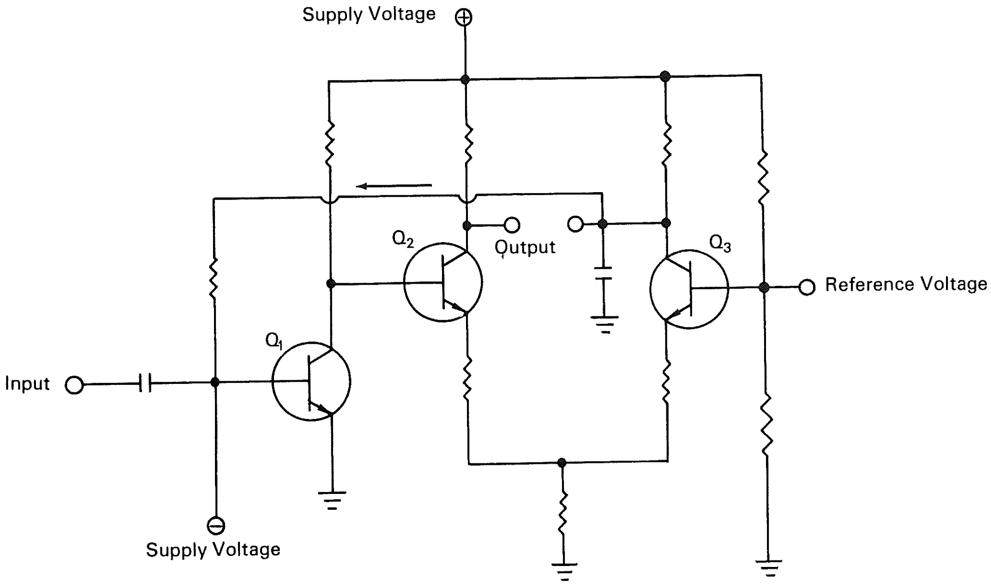
**Patent status:** NASA encourages the immediate commercial use of this invention. It is owned by NASA and inquiries about obtaining royalty-free rights for its commercial use may be made to NASA, Code AGP, Washington, D.C., 20546.

Source: William W. Bond
(JPL-675)

May 1965 Brief 65-10138

# NASA TECH BRIEF

## High-Gain Amplifier Has Excellent Stability and Low Power Consumption



**The problem:** High-gain transistorized amplifiers have been relatively unstable. Most circuits designed for both high gain and stability draw excessive power. For many equipment applications, a need exists for an amplifier combining high gain with stability and low power consumption.

**The solution:** A transistorized amplifier in which gain is controlled by an external reference voltage. Closed-loop gain is about 15,000, and power consumption is very low.

**How it's done:** Gain of the amplifier ($Q_1$) is stabilized by using a difference amplifier circuit ($Q_2$ and $Q_3$) to sense and correct changes in its operating point. The ac gain of $Q_1$ is controlled by its dc operating point. This dc operating point is controlled by the difference amplifier $Q_2$ and $Q_3$ through the feedback loop from the collector of $Q_3$ to the base of $Q_1$. Varying the reference voltage to the base of $Q_3$, therefore, varies the ac gain of the amplifier $Q_1$.

**Notes:**

1. Stability of this circuit depends on the use of quality components including transistors with Beta greater than 100.
2. This circuit should be of interest to manufacturers of electronic servo equipment and portable audio devices.
3. The amplifier can be used as a variable gain modulator if a varying signal is applied to the base of $Q_3$.

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4. Inquiries concerning this invention may be directed to:

Technology Utilization Officer
Goddard Space Flight Center
Greenbelt, Maryland, 20771
Reference: B65-10138

**Patent Status:** NASA encourages the immediate commercial use of this invention. Inquiries about obtaining rights for its commercial use may be made to NASA, Code AGP, Washington, D.C., 20546.

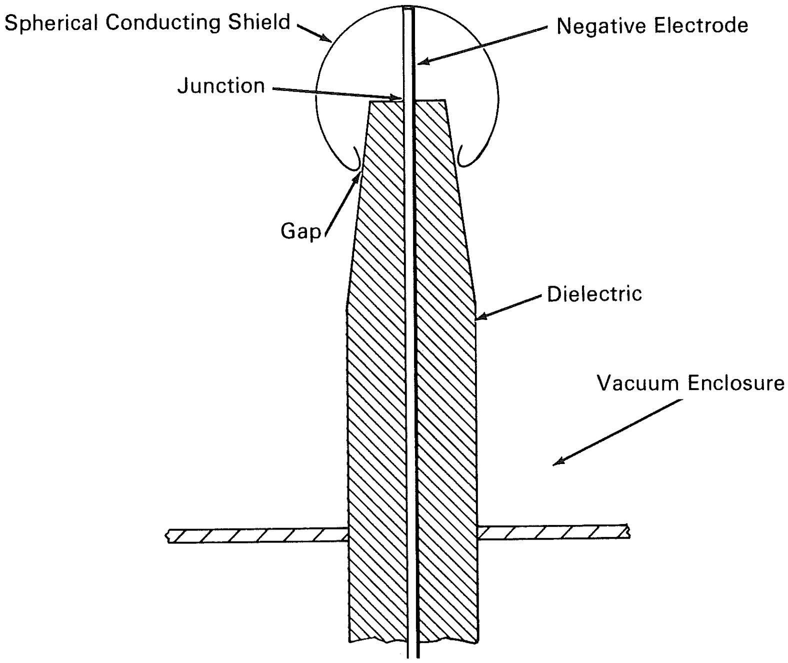
Source: Leonard L. Kleinberg
(GSFC-272)

May 1965

Brief 65-10139

# NASA TECH BRIEF

## Spherical Electrode Eliminates High-Voltage Breakdown



**The problem:** Insulation breakdown and electrical leakage at the negative electrode-dielectric junction in high-voltage vacuum feedthroughs and insulators. Designs in which the electrode is cast into the dielectric or in which a current leakage path is used to equalize stress must be large in size to handle high voltages, or they may also suffer from inherent power losses.

**The solution:** The use of a spherical electrode (conducting shield) to surround the negative electrode-dielectric junction.

**How it's done:** The spherical electrode is positioned so that the junction of the electrode and the dielectric is at an appropriate point in the sphere where the electrostatic potential and stresses are near zero. The gap between the spherical electrode and the dielectric must be of optimum size for proper operation. Too large a gap may not provide adequate junction shielding, whereas a small gap can result in hazardous radiation at high voltages.

### Notes:

1. With appropriate modification, this electrode should be suitable as a high-voltage feedthrough between various liquid and gaseous media, as well as in high-vacuum environments.

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2. Inquiries concerning this invention may be directed to:

   Technology Utilization Officer
   Lewis Research Center
   21000 Brookpark Road
   Cleveland, Ohio, 44135
   Reference: B65-10139

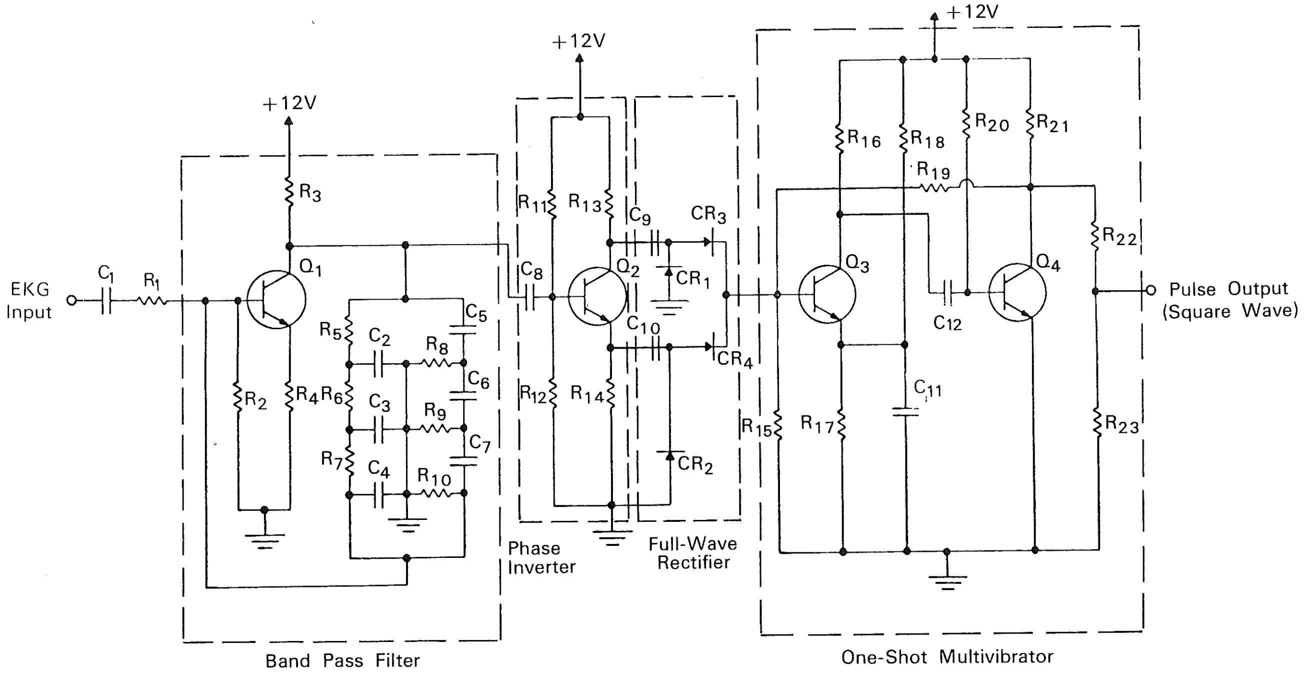
**Patent status:** NASA encourages the immediate commercial use of this invention. Inquiries about obtaining rights for its commercial use may be made to NASA, Code AGP, Washington, D.C., 20546.

Source: R. C. Finke and R. H. Vetrone
(Lewis-155)

May 1965 Brief 65-10142

# NASA TECH BRIEF

## Auxiliary Circuit Enables Automatic Monitoring of EKG's


+12V
EKG Input
C1
R1
R2
R3
Q1
R4
R5
R6
R7
C2
C3
C4
R8
R9
R10
C5
C6
C7
+12V
R11
R13
R12
R14
C8
Q2
C9
C10
CR1
CR2
CR3
CR4
Phase Inverter
Full-Wave Rectifier
+12V
R16
R18
R19
R20
R21
R22
Q3
Q4
C12
C11
R15
R17
R23
Pulse Output (Square Wave)
Band Pass Filter
One-Shot Multivibrator

**The problem**: Monitoring of electrocardiograms by digital computers. Relatively little difficulty is encountered in analyzing cardiac activity from visual inspection of the QRS waveforms or complex (electrical potential developed by depolarization of the heart ventricles) on an electrocardiogram (EKG) in the presence of interfering signals. These signals can arise from the 60 cps powerlines, the electromyogram (electrical potentials produced by muscular action), baseline changes due to breathing and pickup-electrode movements, unusually large T-waves (which represent the restoration of the polarized state of the ventricles), and changes in magnitude or polarity of the QRS complex. However, both because of the obscuring effect of the noise signals and the analog form of the EKG, the output of conventional electrocardiographs or cardiotachometers cannot be directly monitored by digital computers.

**The solution**: An auxiliary circuit that produces a noise-free square-wave output signal each time it receives a trigger pulse (R-wave) from an EKG preamplifier.

**How it's done**: The input signal from an EKG preamplifier is processed through a bandpass filter (which is sharply tuned to the predominant frequency of the QRS complex) to reject extraneous frequency components. The filtered signal is fed into a hybrid full-wave rectifier (one-half of which is fed through a phase inverter), which thus utilizes either positive or

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negative initial waveforms to trigger a one-shot multivibrator circuit. The duration of a square-wave pulse from the multivibrator is adjusted to 300 milliseconds to eliminate all extraneous trigger sources and allow for heart rates up to 200 beats per minute.

Capacitor $C_1$ and resistor $R_1$ form a dc blocking and matching unit between the EKG preamplifier and the active filter consisting of transistor $Q_1$ and the filter network $R_5$ through $R_{10}$ and $C_2$ through $C_7$. The filter circuit provides positive feedback at the resonant frequency and negative feedback at frequencies above or below the resonant frequency. Transistor $Q_2$, dc-biased by $R_{11}$ and $R_{12}$, acts as a phase inverter which feeds into a hybrid voltage-doubling, full-wave rectifier. Resistor $R_{17}$ and capacitor $C_{11}$ eliminate triggering by transients of the one-shot multivibrator, $Q_3$-$Q_4$. The trigger amplitude is determined by the voltage divider $R_{17}$-$R_{18}$. The square-wave output pulse, which has a time duration determined by $C_{12}$ and $R_{20}$, is obtained from the divider network consisting of $R_{22}$ and $R_{23}$. This output pulse can be fed directly into a magnetic tape recorder, strip chart recorder, or digitizing circuitry for computer programing.

## Notes:

1. The output pulse from this circuit can also be used for locating the time of occurence of the QRS complex in relation to an intra-arterial blood-pressure tracing.
2. This circuit should be useful for accurate automatic processing of large amounts of cardiovascular data (EKG and intra-arterial blood pressure) from analog tapes.
3. A circuit that converts the output from this auxiliary circuit into pulses which can be applied to a direct-reading digital voltmeter is described in NASA Tech Brief B65-10143, May 1965.
4. A cardiotachometer which provides an analog indication of average heart rate is described in NASA Tech Brief B65-10010, January 1965.
5. Inquiries concerning this invention and those cited above may be directed to:

   Technology Utilization Officer
   Manned Spacecraft Center
   P.O. Box 1537
   Houston, Texas, 77001
   Reference: B65-10142

**Patent status:** NASA encourages the immediate commercial use of this invention. It is owned by NASA and inquiries about obtaining royalty-free rights for its commercial use may be made to NASA, Code AGP, Washington, D.C., 20546.

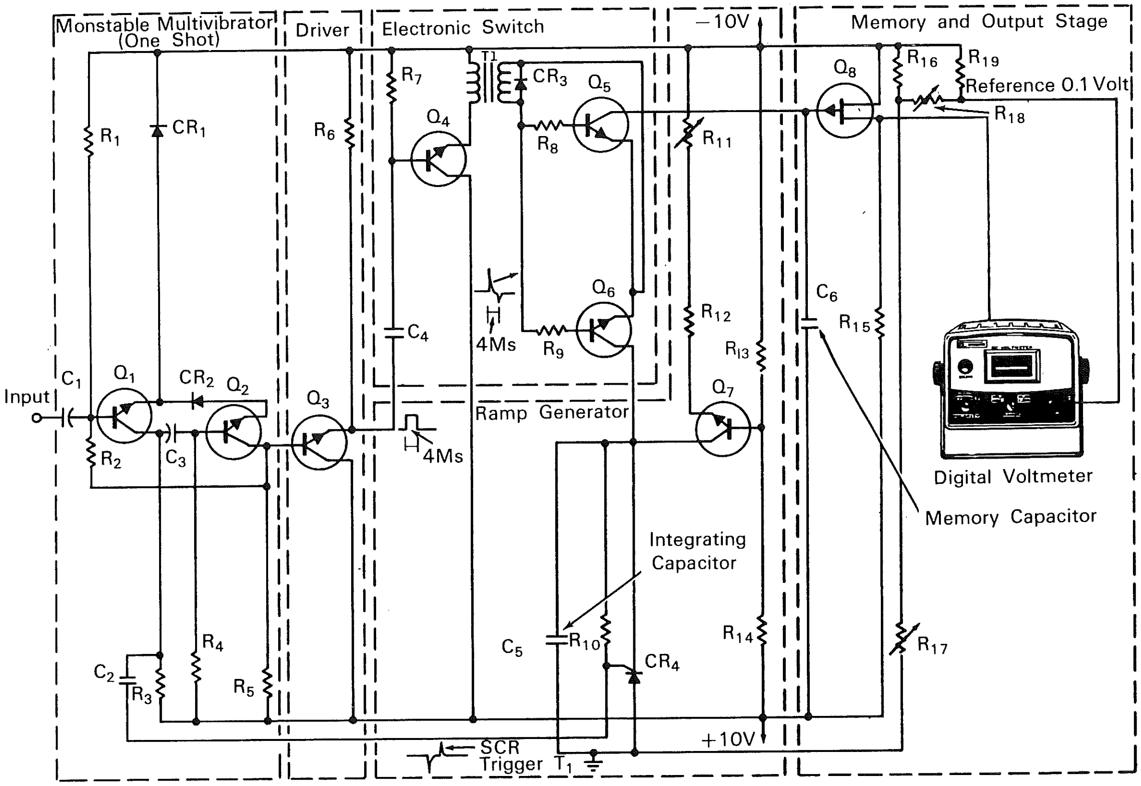
Source: Texas Institute for Rehabilitation and Research
under contract to Manned Spacecraft Center
(MSC-106)

May 1965

Brief 65-10143

# NASA TECH BRIEF

## Digital-Output Cardiotachometer Measures Rapid Changes in Heartbeat Rate


Monstable Multivibrator (One Shot)
Driver
Electronic Switch
−10V
Memory and Output Stage
T1
R7
CR3
Q5
Q4
R8
Q8
R16
R19
Reference 0.1 Volt
R18
R1
CR1
R6
R11
Q6
C6
R12
R15
C4
4Ms
R9
R13
Q7
Input
C1
Q1
CR2
Q2
Q3
Ramp Generator
4Ms
R2
C3
Digital Voltmeter
Memory Capacitor
Integrating Capacitor
R4
C5
R10
CR4
R14
R17
C2
R3
R5
+10V
SCR Trigger
T1

**The problem**: Analog cardiotachometers are inherently nonlinear and do not respond with sufficient speed to indicate rapid changes in heartbeat rate. Those digital cardiotachometers that are capable of measuring heartbeat rate on a beat-by-beat basis are generally complex and costly.

**The solution**: A cardiotachometer circuit that produces an output voltage proportional to the heartbeat rate on a beat-by-beat basis. Direct readings in beats per minute are obtained on a linear scale of a digital voltmeter. This circuit is designed to be used with an auxiliary circuit (described in NASA Tech Brief B65-10142, May 1965) that converts a subject's electrocardiogram into square-wave pulses at a frequency proportional to the heartbeat rate.

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**How it's done:** The square-wave pulses from the auxiliary circuit are applied as the input to the cardiotachometer. These pulses trigger the monostable multivibrator ($Q_1$-$Q_2$) which converts them into short-duration (4-millisecond) square-wave pulses. The narrow pulses pass through the driver stage, $Q_3$, and are differentiated in the $Q_4$ emitter and $T_1$ transformer circuit. The positive-going portion of the differentiated square wave appearing on the secondary of $T_1$ passes to the base elements of the normally cut off switching transistors $Q_5$ and $Q_6$. On receipt of a positive pulse, these transistors are turned on to transfer the voltage developed on integrating capacitor $C_5$ to the memory capacitor $C_6$. A few milliseconds later, the silicon controlled rectifier (SCR), $CR_4$, is triggered and shorts out the charge on $C_5$. The SCR then returns to the quiescent state and $C_5$ becomes ready to start another cycle when the next positive pulse appears.

Capacitor $C_5$ is sampled and then shorted out each time a 4-millisecond pulse is generated. The time between pulses is relatively long (0.3 to 3 seconds). During this interval, $C_5$ will continue to charge at a linear rate through $Q_7$ toward $-10$ volts, until the next heart beat (4-millisecond pulse) activates the switching transistors to transfer the charge from $C_5$ to $C_6$. Transistor $Q_7$ provides the constant-current source necessary for a linear charge rate, so that the amplitude of the ramp voltage on $C_5$ is a function of the time between heart beats.

The charge on $C_6$ biases the field effect transistor, $Q_8$, to control the current through $R_{15}$. Since a field effect transistor is a high-impedance device, the charge on $C_6$ will not leak off between pulses. The voltage across $R_{15}$ is therefore a function of this charge. This output voltage is applied to a commercial digital voltmeter in a unique manner. Normally the voltage would be applied to the voltmeter's input terminals. Instead, the output voltage is applied to the voltage reference circuit inside the meter case and a 0.1-volt reference is applied to the input terminals. The digital voltmeter is thus connected as an electronic divider or ratiometer to provide readings of the heartbeat rate directly in beats per minute.

## Notes:

1. An analog cardiotachometer is described in NASA Tech Brief B65-10010, January 1965. Inquiries may also be directed to:

   Technology Utilization Officer
   Manned Spacecraft Center
   P.O. Box 1537
   Houston, Texas, 77001
   Reference: B65-10143

**Patent status:** NASA encourages the immediate commercial use of this invention. Inquiries about obtaining rights for its commercial use may be made to NASA, Code AGP, Washington, D.C., 20546.

Source: Howard Vick
(MSC-133)

May 1965

Brief 65-10145

NASA TECH BRIEF

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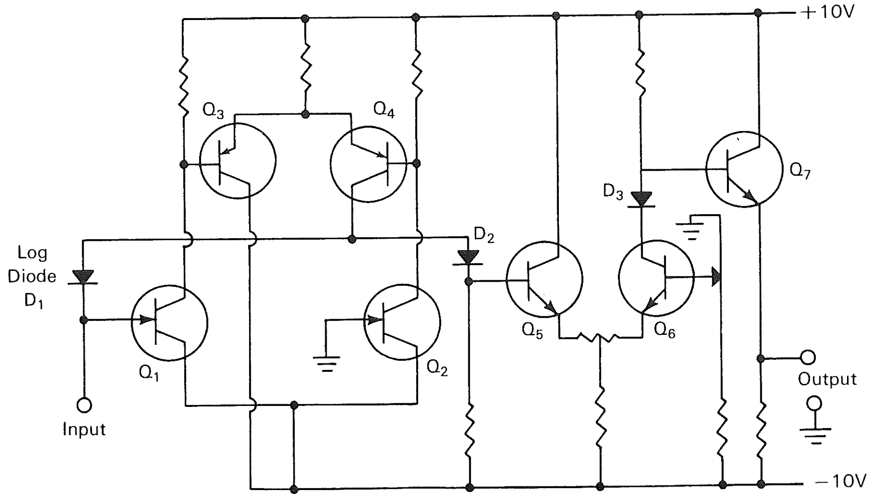
# Logarithmic Amplifier Uses Field Effect Transistors



**The problem:** Some instrumentation and recording applications require a logarithmic response to an input signal having a range of current variation from $10^{-12}$ to $10^{-4}$ ampere. Temperature compensation also is required.

**The solution:** A solid-state amplifier that utilizes field-effect transistors and planar junction diodes. This circuit has a logarithmic response to signals ranging from $10^{-12}$ to $10^{-4}$ ampere.

**How it's done:** The basic circuit is a temperature-stabilized amplifier composed of three differential amplifier stages, an emitter-follower output stage, and a planar-junction logarithmic diode.

The required response to an unusually large range of input current variation is achieved by using two n-channel field-effect transistors, $Q_1$ and $Q_2$, for the first differential amplifier stage. Because of the very high input impedance exhibited by these transistors, they are also sensitive to very small currents.

The two field effect transistors, $Q_1$ and $Q_2$, drive the second differential amplifier stage, $Q_3$ and $Q_4$. The output of $Q_3$ is applied to the final differential amplifier stage, $Q_5$ and $Q_6$, and to the planar-junction logarithmic diode, $D_1$. By inserting $D_1$ in the feedback path to the first differential amplifier stage, the logarithmic output of the circuit is achieved.

The output of $Q_6$ is applied to $Q_7$, which is operated as an emitter-follower. This configuration provides a high output impedance for the amplifier. The differential amplifier structure of the circuit provides temperature compensation.

**Notes:**

1. For optimum overall characteristics, the components should be matched.
2. The final output voltage, $E_o$, taken between the emitter of $Q_7$ and ground, will be

$$E_o = K_1 \log (5 \times 10^{11} I_{in} + 1) + K_2$$

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3. Inquiries concerning this innovation may be directed to:

    Technology Utilization Officer
    Jet Propulsion Laboratory
    4800 Oak Grove Drive
    Pasadena, California, 91103
    Reference: B65-10145

**Patent status:** NASA encourages commercial use of this innovation. No patent action is contemplated.

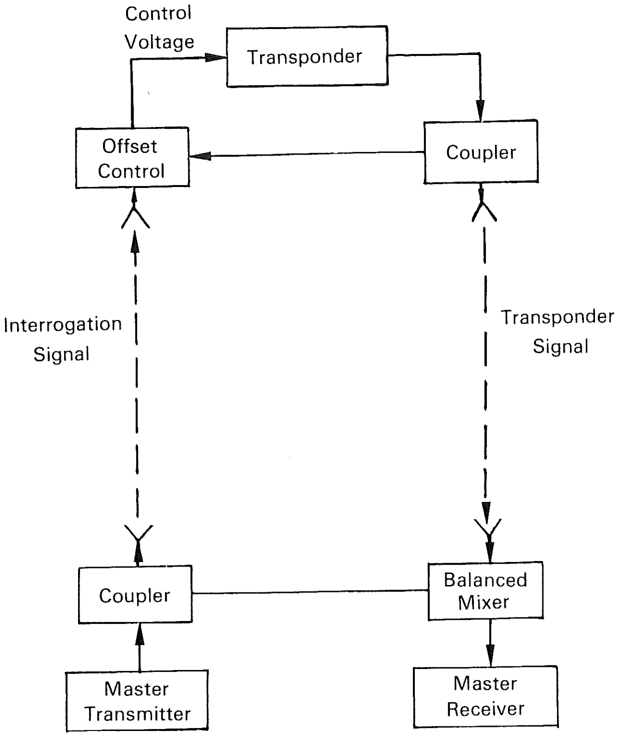
Source: J.L. Stewart
(JPL-509)

May 1965

Brief 65-10146

# NASA TECH BRIEF

## Frequency Offset In Linear FM/CW Transponder Eliminates Clutter



**The problem:** To eliminate false echoes or reflections (clutter) of the signal used to interrogate the linear FM/CW transponder located on airborne vehicles.

**The solution:** Offset the frequency of the transponder signal with respect to the interrogation signal.

**How it's done:** As shown in the illustration, the interrogation signal from the master transmitter is radiated through a coupler to the airborne transponder. The transponder receives this signal through an offset control. The offset control generates a control voltage by comparing the frequency of the interrogation signal to that of the transponder signal. This control voltage changes the frequency of the transponder signal so that it remains constantly offset from the frequency of the interrogation signal. At the master receiver, a portion of the interrogation signal is coupled to a balanced mixer. The transponder signal received by the master receiver is beat against the interrogation signal. The frequency of the beat signal is proportional to transponder range, provided the system is using an FM/CW altimeter. In an FM/CW

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altimeter using linear modulation, the frequency difference associated with a range between two points is: f = f 2R/C where f is the sweep rate, R is the range, and C is the velocity of light. Without frequency offset, the frequency of the beat signal in the master receiver is also a function of transponder time delay. Because of this, signals reflected from false targets whose time delays, because of range, are equal to that of the desired signal will be indistinguishable from the desired signals. These undesirable signals are eliminated by offsetting the transponder frequency.

**Notes:**

1. Suggested application is in any situation where tracking an aircraft or space vehicle is to be performed using FM/CW transponders.
2. Inquiries concerning this innovation may be directed to:

Technology Utilization Officer
Marshall Space Flight Center
Huntsville, Alabama, 35812
Reference: B65-10146

**Patent status:** NASA encourages commercial use of this innovation. No patent action is contemplated.

Source: Melpar, Incorporated
under contract to Marshall Space Flight Center
(M-FS-249)

June 1965

Brief 65-10158

# NASA TECH BRIEF

## Laser Beam Transmits Electric Power

**The problem:** To supply a sustained level of electrical power to a location that cannot be served by conventional conductors.

**The solution:** A semiconductor laser beam is directed to a remote photovoltaic cell where its light energy is converted to a constant electrical power level.

**How it's done:** Emission is stimulated in a gallium arsenide p-n junction to form a high density laser beam. This beam is directed to the remote location that cannot be reached by electrical conductors. The beam is detected by a gallium arsenide photodiode and reconverted to an electrical current. This steady, sustained current is then used to operate a device.

**Notes:**

1. This system, while effective, suffers from an appreciable loss factor which reduces its efficiency to a quite low level. It would only be useful in an application where the transmission of energy was critical and could not be accomplished in any other way.
2. This innovation could be used to operate equipment located in a hazardous environment such as near or in a nuclear reactor or an extremely reactive chemical atmosphere.
3. Inquiries concerning this innovation may be directed to:

Technology Utilization Officer
Goddard Space Flight Center
Greenbelt, Maryland, 20771
Reference: B65-10158

**Patent status:** NASA encourages commercial use of this innovation. No patent action is contemplated.

Source: Radio Corporation of America under contract to Goddard Space Flight Center
(GSFC-293)

Category No. 01

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June 1965 Brief 65-10159

# NASA TECH BRIEF

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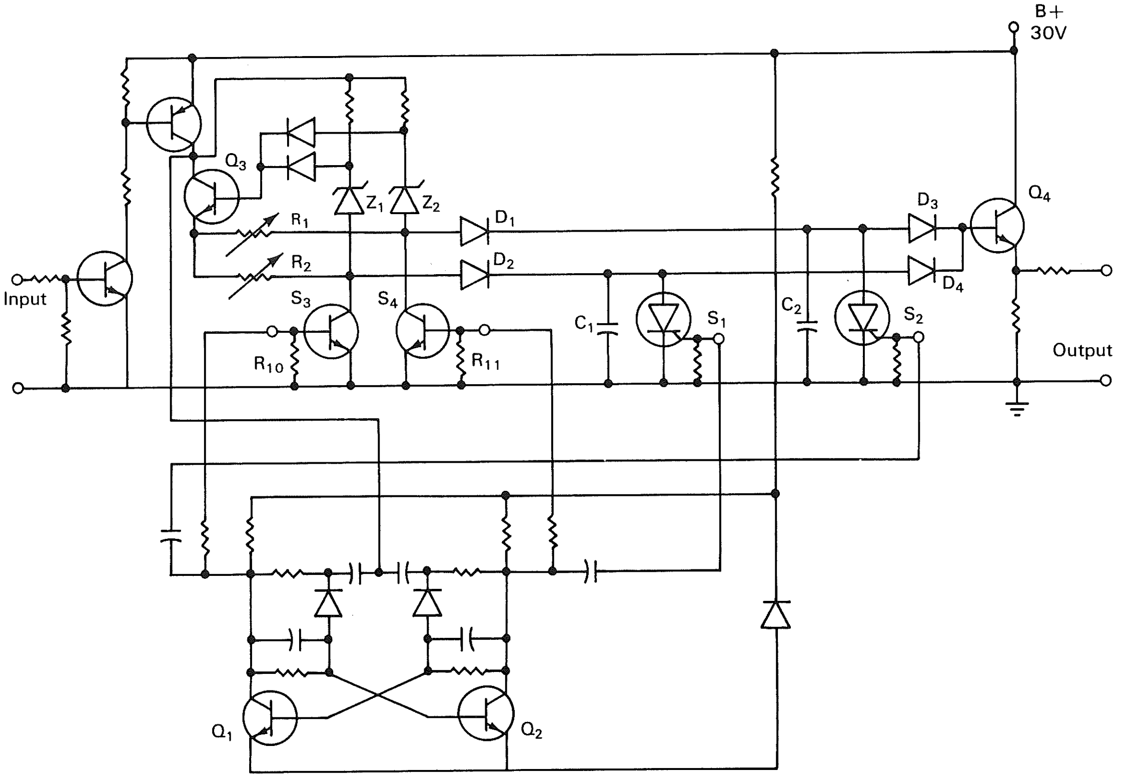
## Solid-State Switching Used to Speed Up Capacitive Integrator



**The problem:** Where the width of variable electric pulses is of interest, as in a control system that indicates certain parameter changes by changes in pulse width, a method of converting the pulses to an analog voltage is needed in order to measure such pulse width. Conventional capacitive integrators that perform this conversion use relays for switching the capacitors. Relays have limited operating lifetime, draw appreciable power, and cannot be switched in much less than two milliseconds.

**The solution:** A capacitive integrator that uses silicon controlled switches (SCS's) to steer each input pulse to the proper capacitor ($C_1$ or $C_2$) in a sequence of charge, discharge, and read. The circuit has a response time in microseconds.

**How it's done:** The silicon transistors $S_1$ and $S_2$ are alternately biased on by the bistable multivibrator formed by $Q_1$ and $Q_2$, which is triggered by the trailing edge of each input pulse. At the end of each pulse,

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the capacitor that is next to be charged is unloaded of its previous charge by a shunted silicon controlled switch ($S_3$ or $S_4$) that is also triggered by the multivibrator. Blocking diodes $D_1$ and $D_2$ prevent discharge of the capacitors ($C_1$ and $C_2$) through the charge components. Capacitors $C_1$ and $C_2$ are charged by the constant current circuit $Q_3$, $Z_1$, $Z_2$, $R_1$, and $R_2$. This circuit insures an output voltage that is linearly proportional to the input pulse width. Maximum linear output voltage level is determined by the zener voltage of $Z_1$ and $Z_2$ and the magnitude of the input pulse since: $V_{out} = V_{in} - V_{out} = V_{B+} - 2V_Z$. Capacitors $C_1$ and $C_2$ are connected to the base of the combined emitter follower $Q_4$ through $D_3$ and $D_4$. This circuit exhibits an output equal in magnitude to the highest voltage appearing on either $C_1$ or $C_2$. It also provides a high input impedance (500K ohms) to prevent transient discharge of the capacitors, while maintaining a relatively low output impedance.

System output can be considered as an integral function of the input on a single pulse basis, or as an RMS (root mean square) equivalent of a series of evenly spaced pulses.

**Notes:**

1. A modified version of this circuit has been used successfully for over eight months to integrate the output of an infrared horizon scanner for space exploration.
2. The circuit can be used to integrate either high or low duty cycle pulses with repetition rates ranging from 1 pulse per second to over 10,000 pulses per second with negligible ripple factors.
3. Inquiries concerning this innovation may be directed to:

Technology Utilization Officer
Langley Research Center
Langley Station
Hampton, Virginia, 23365
Reference: B65-10159

**Patent status:** NASA encourages the immediate commercial use of this invention. Inquiries about obtaining rights for its commercial use may be made to NASA, Code AGP, Washington, D.C., 20546.

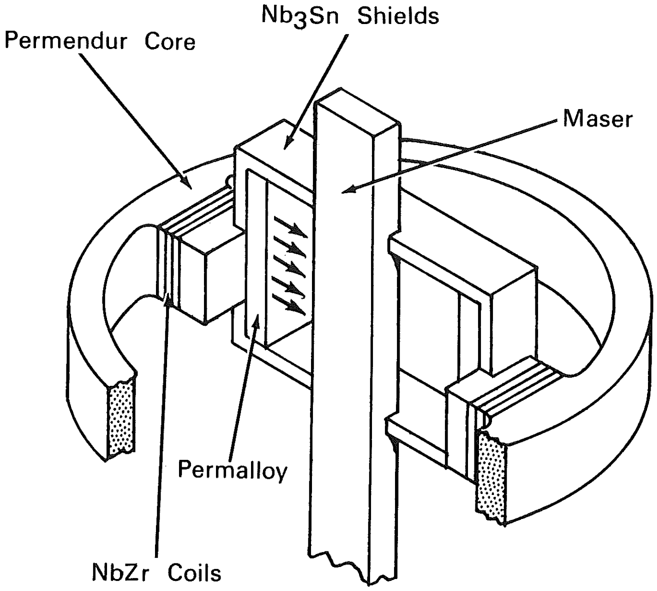
Source: Arthur L. Newcomb, Jr.
(Langley-104)

June 1965

Brief 65-10165

# NASA TECH BRIEF

## Superconductor Magnets Used for Stagger-Tuning Traveling-Wave Maser



**The problem:** The bandwidth of a traveling-wave maser can be increased by stagger-tuning the individual maser crystals. Since the operating frequency of a crystal depends on the strength of the applied magnetic field, a stagger-tuned maser requires a series of magnetic fields, each having a different field strength. A large, heavy multipole magnet, with a power supply and a method of removing heat, has been required to produce these fields. Such an arrangement also introduces the problem of flux leakage, field fringing, and nonuniformity of the magnetic field.

**The solution:** The use of superconducting materials to reduce the size and weight of the magnet. Flux leakage, fringing, and nonuniformity of the field are eliminated by placing superconducting shields around the individual fields.

**How it's done:** The magnet uses "hard" superconductors, which can tolerate high current density and intense magnetic fields before going resistive. The magnet can be brought up to full power very easily, and requires no power source once the field is established. The core of the magnet uses high-flux-saturation, low-permeability material. The superconductor coils are wound with the proper number of turns to produce the required magnetic field. The superconductor shields force the individual magnetic fields to be uniform along each individual crystal.

**Notes:**

1. The superconductor shields consist of a ceramic material coated on both sides with vapor-deposited $Nb_3Sn$.
2. This invention is applicable to any microwave

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communications system that requires a high information rate.

3. Inquiries concerning this invention may be directed to:

Technology Utilization Officer
Goddard Space Flight Center
Greenbelt, Maryland, 20771
Reference: B65-10165

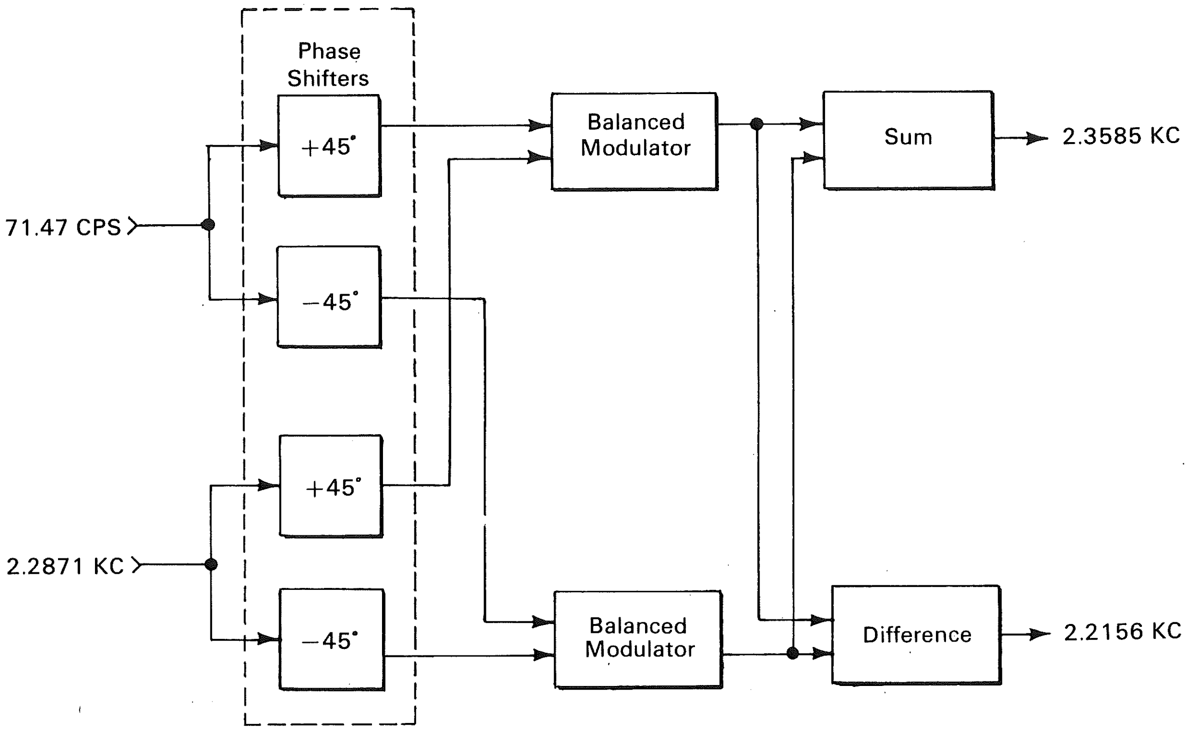
**Patent status:** NASA encourages the immediate commercial use of this invention. Inquiries about obtaining rights for its commercial use may be made to NASA, Code AGP, Washington, D.C. 20546.

Source: Radio Corporation of America
under contract to Goddard Space
Flight Center
(GSFC-292)

June 1965 Brief 65-10169

# NASA TECH BRIEF

## Phase Shift Frequency Synthesizer Is Efficient, Small in Size



**The problem:** Producing sum and difference signals while suppressing all undesired frequencies. Space and weight considerations rule out the use of bulky and heavy reactive components and crystal filters usually employed to suppress unwanted frequencies.

**The solution:** A phase shift frequency synthesizer that produces suppressed-carrier signals at the sum and difference frequencies.

**How it's done:** Each of the 2 inputs to this circuit are divided and phase shifted to obtain signals with a ±45° phase relative to the respective input. These signals are then used to drive 2 identical balanced modulators. The balanced modulator outputs contain both sidebands with the carrier suppressed. Relative phase of the sidebands are such that, if linearly added, the first sideband will be cancelled and the second reinforced; if differenced, the second sideband will be cancelled and the first reinforced. In this way two coherent signals, very close in frequency but isolated from each other, are obtained.

**Notes:**

1. In this circuit, the unwanted signals associated with each output were suppressed a minimum of 40 db below the signal of interest.
2. This circuit would be of value in any application where it is desired to synthesize frequencies from

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input signals, suppress undesired frequencies, and maintain small component and overall package weights and dimensions.

3. Inquiries concerning this innovation may be directed to:

   Technology Utilization Officer
   Marshall Space Flight Center
   Huntsville, Alabama, 35812
   Reference: B65-10169

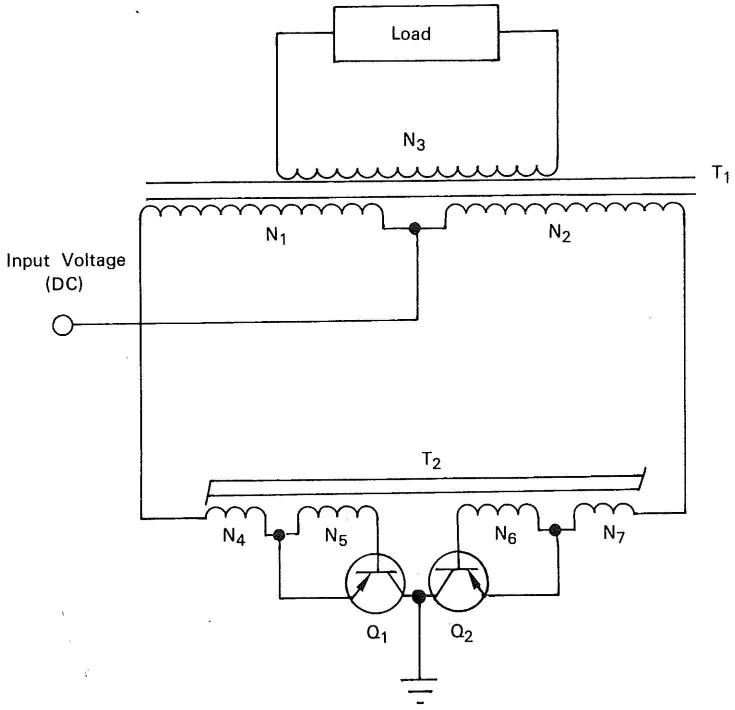
**Patent status**: NASA encourages commercial use of this innovation. No patent action is contemplated.

Source: Space Technology Laboratories, Inc.
under contract to Marshall Space
Flight Center
(M-FS-250)

June 1965 Brief 65-10178

# NASA TECH BRIEF

## DC to AC Converter Operates Efficiently at Low Input Voltages



**The problem:** Designing an efficient dc to ac converter for low input voltages (0.5 to 4.0 volts). Recently developed electrical power sources (fuel cells, thermionic diodes, thermoelectric generators, and solar cells) produce high-current, low-voltage dc outputs which must be converted to ac for many applications. Since the output voltages from these power sources are very low, the converter used must be extremely efficient. Performance reliability is decreased when a large number of power sources are connected in series to increase the net output voltage to a sufficiently high level for operation with a less efficient converter.

**The solution:** A self-oscillating dc to ac converter which uses transistor switching to produce a square-wave output. The efficiency of the circuit approaches the maximum efficiency of the transistor switches.

**How it's done:** The converter consists of two switching transistors $Q_1$ and $Q_2$, output transformer $T_1$, and a saturable core transformer $T_2$. When a dc input voltage is applied to the circuit, one of the transistors, e.g., $Q_1$, starts to conduct. The emitter-to-base-voltage drop in transistor $Q_1$ appears across winding $N_5$ of transformer $T_2$ and establishes the direction of flux change in the core of $T_2$. When $T_2$ becomes saturated, decoupling occurs between $N_4$ and $N_5$. The base

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current to $Q_1$ decreases and $Q_1$ is turned off. Energy stored in $T_2$ is returned to the circuit and $Q_2$ is turned on. As $T_2$ cyclically saturates and desaturates, the input voltage is impressed first across $N_1$ and then across $N_2$, thereby inducing an alternating square wave in the output winding $N_3$ connected to the load.

**Notes:**

1. This converter is also suitable for use with higher-voltage power sources.
2. Tests have shown that the converter has a high efficiency throughout a wide range of loads. For a 20-ampere dc input, the efficiency increased from 79% at a 1-volt input to 94% at a 3-volt input.
3. The converter is able to withstand relatively large overloads for short time intervals without transistor damage.
4. The transistors should be reasonably well matched. To compensate for the effects of temperature on transistors with dissimilar characteristics, they should be mounted in close proximity on a common heat sink. A high degree of mismatch between the emitter-base voltage drops of the two transistors can be compensated by adjusting the relative number of turns in windings $N_5$ and $N_6$.
5. Inquiries concerning this invention may be directed to:

   Technology Utilization Officer
   Goddard Space Flight Center
   Greenbelt, Maryland, 20771
   Reference: B65-10178

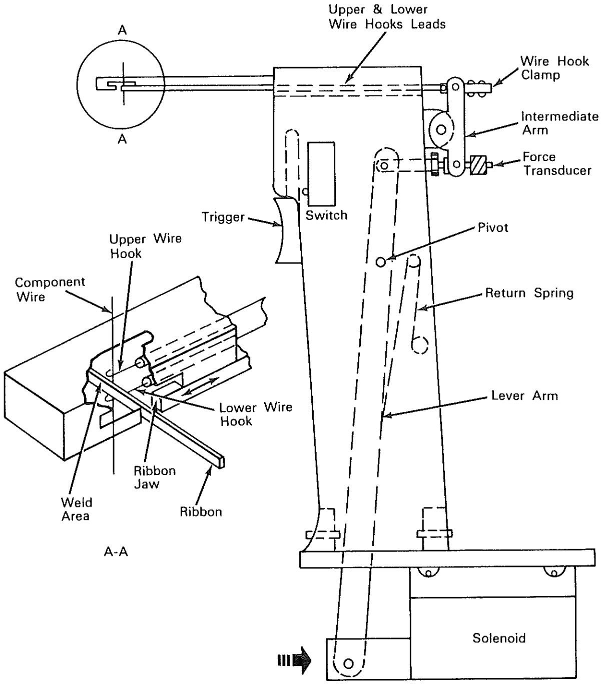
**Patent status:** NASA encourages the immediate commercial use of this invention. It is owned by NASA and inquiries about obtaining royalty-free rights for its commercial use may be made to NASA, Code AGP, Washington, D.C., 20546.

Source: Duke University under contract to
Goddard Space Flight Center
(GSFC-130)

June 1965 Brief 65-10182

NASA TECH BRIEF

# Force Controlled Solenoid Drives Microweld Tester



**The problem:** To test the integrity of a microweld joint between an electronic component lead wire and a wire ribbon. Previous microweld joint testers applied a combination of shear, torsion, and peel. What is desired is a straight-line tension test.

**The solution:** A solenoid-driven tester that applies only a tension stress to the microweld joint. The design provides a variable, measured force so that either destructive or nondestructive testing may be performed.

**How it's done:** A solenoid connected to a lever arm applies the tensile stress, and a force transducer continuously senses the applied force. The jaws of the tester and the ribbon jaws securely clamp the ribbon of the specimen to be tested. Wire hooks are looped around the component lead wire on either side of the weld. When the solenoid is energized, tension is applied to the weld through a lever arm arrangement that links the solenoid to both wire hooks. A wide range of stress forces (to destruction) is available through the rheostat controlled solenoid.

A force transducer mounted on the intermediate arm connection continuously senses the force applied to the weld joint. Readout is on a dc milliammeter.

**Notes:**

1. This device has been used to test weld integrity destructively or nondestructively on components both installed and not installed in modules.

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2. This innovation should be of value in quality control where future operating stresses can be predicted.
3. Inquiries concerning this innovation may be directed to:

Technology Utilization Officer
Western Operations Office
150 Pico Boulevard
Santa Monica, California, 90406
Reference: B65-10182

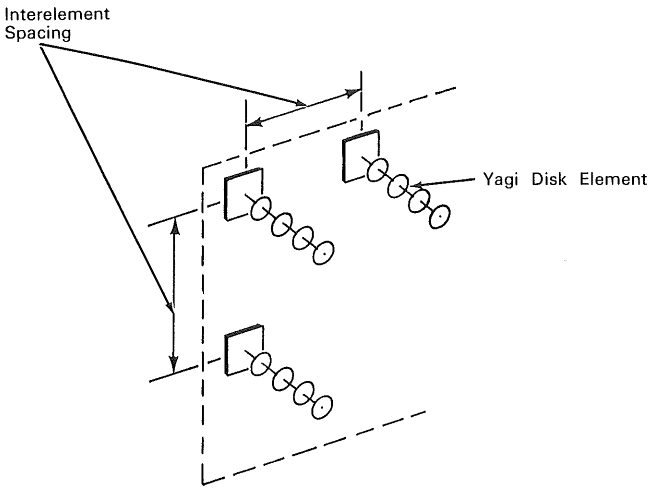
**Patent status**: NASA encourages commercial use of this innovation. No patent action is contemplated.

Source: North American Aviation Company under contract to Western Operations Office
(WOO-125)

June 1965 Brief 65-10183

# NASA TECH BRIEF

## Modified Interelement Spacing Improves Yagi Antenna Array



**The problem:** The design of Yagi disk antenna arrays can be based on simple array theory and a knowledge of the field pattern of a single Yagi disk element. To design a symmetrical array on this basis requires interelement spacing of at least one wavelength to minimize interelement coupling. Interelement spacing of this magnitude, however, introduces spurious sidelobes (grating lobes) in the array pattern.

**The solution:** Adjust the Yagi disk interelement spacing so that the grating lobe of the array factor coincides with the first sidelobe of the element pattern.

**How it's done:** The radiation pattern of a Yagi disk antenna array is the product of the array factor and the element pattern if interelement coupling is negligible. Adjusting interelement spacing to make the grating lobe of the array factor coincident with the first sidelobe of the element pattern results in negligible interelement coupling and considerably reduces the amplitude of the grating lobe. Although the grating lobe could be reduced even further by adjusting interelement spacing to make the grating lobe coincident with the null between the main lobe and first sidelobe in the element pattern, this adjustment would make the amplitude of the grating lobe frequency-sensitive. Since there is negligible interelement coupling, and since no excessive energy is lost in grating lobes, the gain of an entire array can be predicted from a knowledge of the gain of a single element.

**Note:** Inquiries concerning this innovation may be directed to:

Technology Utilization Officer
Langley Research Center
Langley Station
Hampton, Virginia, 23365
Reference: B65-10183

**Patent status:** NASA encourages commercial use of this innovation. No patent action is contemplated.

Source: Fred B. Beck
(Langley-130)
Category No. 01

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June 1965 Brief 65-10184

# NASA TECH BRIEF

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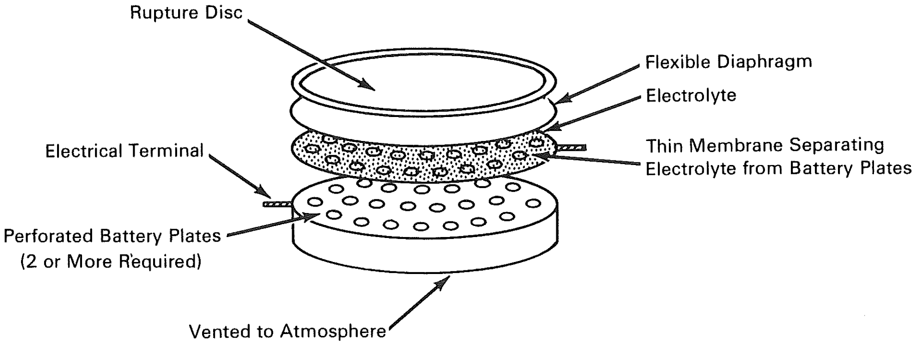
## Pressure Sensor Responds Only to Shock Wave


Rupture Disc
Flexible Diaphragm
Electrolyte
Electrical Terminal
Thin Membrane Separating Electrolyte from Battery Plates
Perforated Battery Plates (2 or More Required)
Vented to Atmosphere

**The problem:** Simple pressure transducers or pressure switches are sensitive to overpressures as well as to shock waves and cannot be used to identify either. A device is needed that is sensitive only to the high pressure crest of a shock wave but will not respond to conditions of overpressure.

**The solution:** A sensor that uses the force of a shock wave to energize the plates of a battery to produce a voltage. The sensor remains inoperative in the presence of overpressure forces.

**How it's done:** The device is made up of two major parts, a rupture disk and a sensor. The sensor, directly beneath the rupture disk, consists of a flexible diaphragm, a cavity filled with electrolyte, a thin membrane, two or more perforated battery plates, and a backing plate that is vented to the atmosphere. A shock wave consists of a very high pressure crest preceded and followed by much lower pressure. This pressure formation acts to shatter the rupture disk and drive it into the sensor, since the backing plate of the sensor is vented to the lower pressure preceding the shock wave crest. The shattered disk permits the pressure of the shock wave crest to be impressed on the electrolyte-filled cavity through the flexible diaphragm. The electrolyte, being noncompressible, ruptures the thin membrane through the battery plate perforations and contacts the battery plates, producing a voltage. This voltage is routed to desired instrumentation by the battery plate terminals.

**Notes:**

1. The output voltage can be used to actuate an alarm signal or crew escape system and could be combined with other instrumentation in a "decision" circuit or "coincident" circuit to perform varied functions.
2. The invention requires no external power.
3. The invention has fast response and full output voltage can be reached by the time the shock wave has travelled the depth of the sensor, a distance of one inch.
4. This is a "one-time" device and would have to be rebuilt or replaced after each use.
5. Inquiries concerning this invention may be directed to:

   Technology Utilization Officer
   Marshall Space Flight Center
   Huntsville, Alabama, 35812
   Reference: B65-10184

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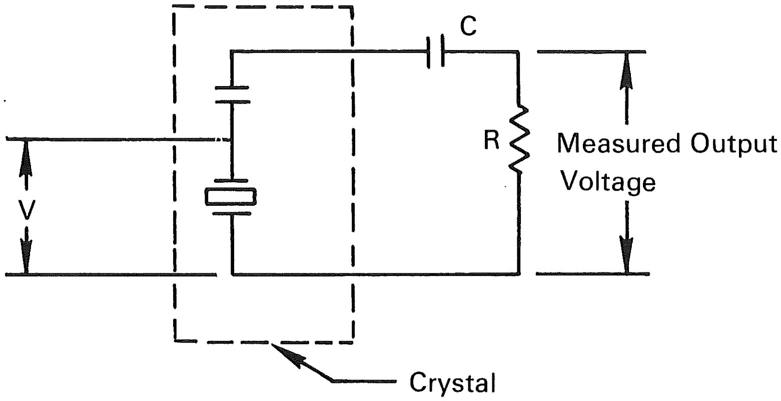
**Patent status:** NASA encourages the immediate commercial use of this invention. It is owned by NASA and inquiries about obtaining royalty-free rights for its commercial use may be made to NASA, Code AGP, Washington, D.C., 20546.

Source: The Boeing Company under contract
to Marshall Space Flight Center
(M-FS-238)

June 1965 Brief 65-10187

# NASA TECH BRIEF

## Crystal Measures Short-Term, Large-Magnitude Forces



**The problem:** To measure transient accelerations and their rate of change associated with high frequency vibrations and shock.

**The solution:** A device that uses the characteristic response of a piezoelectric crystal to distortion and compression. Output of the crystal is fed to an integrating circuit that measures its magnitude, which is proportional to the physical force acting on the crystal.

**How it's done:** When a force is applied to a piezoelectric crystal, a charge proportional to the force is driven off the crystal. The device measures the rate of change of force applied by acceleration by measuring the rate of change of the electrical charge. The device consists of a crystal and an integrating circuit made up of an arbitrary capacitance C and an arbitrary resistance R. The voltage output of the crystal is applied to the integrating circuit. The resulting voltage across the resistance R is proportional to the rate of change of acceleration. This design achieves a time constant large enough for adequate sensitivity yet small enough to accommodate conventional ranges of frequency input.

**Notes:**

1. This would be a useful device to supplement an accelerometer and take over its function when its range was exceeded.
2. The device could be used in a servo control system that is subject to derivatives higher than acceleration.
3. Inquiries concerning this innovation may be directed to:

   Technology Utilization Officer
   Jet Propulsion Laboratory
   4800 Oak Grove Drive
   Pasadena, California, 91103
   Reference: B65-10187

**Patent status:** NASA encourages commercial use of this innovation. No patent action is contemplated.

Source: Carl G. Pfeiffer
(JPL-77)
Category No. 01

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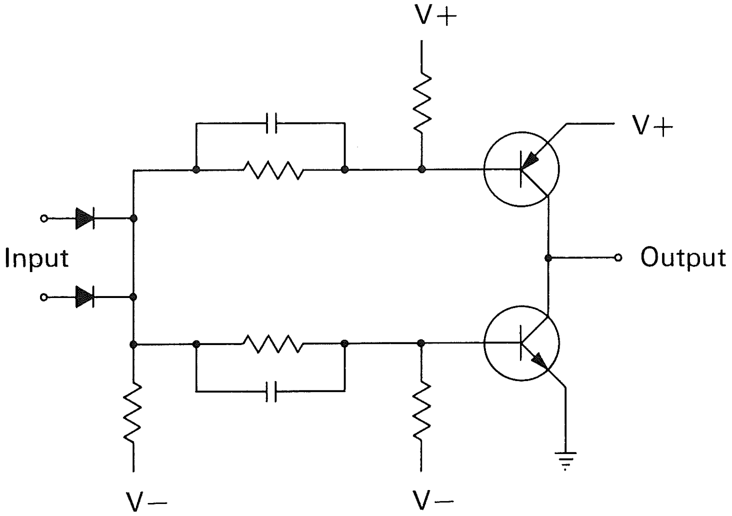
June 1965 Brief 65-10193

# NASA TECH BRIEF

## Logic Circuit Exhibits Optimum Performance



**The problem:** Microelectronic digital circuits are available in many forms of logic and are applicable to many systems used in telemetry and programing. No thorough, comprehensive evaluation of these circuit configurations has been made in terms of power drain, propagation time, or component variations with temperature and load.

**The solution:** To compare the performance of basic logic circuits to determine the optimum circuit configuration for implementation into microelectronic functions.

**How it's done:** Seven basic logic circuits were evaluated to determine their performance as NAND and NOR gates, universal flip-flops, and applicable circuits to utilize flip-flops as shift accumulators. The circuits evaluated were Direct Coupled Transistor Logic (DCTL), Resistor-Transistor Logic (RTL), Resistor-Diode-Transistor Logic (RDTL), Emitter Coupled Transistor Logic (ECTL), Transistor-Transistor Logic (TTL), Diode-Transistor Logic (DTL), and Complementary RDTL.

The design constraints imposed on the circuits limited maximum resistance values to 100,000 ohms, power supply voltages to multiples of ±1.35 volts, propagation time to less than 1 microsecond, and repetition rate to 150 kcps.

On the basis of the test results, complementary RDTL offered the best trade-off performance within these constraints and state-of-the-art fabrication technology. This circuit configuration permits NAND and NOR functions to be easily fabricated with similar design and performance characteristics. Switching speeds

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are high, and propagation time degrades only slightly at high temperatures. Noise immunity is good. Fanout requirements impose a high, but not prohibitive beta requirement. Flip-flop power drain is not excessive. AC set and reset are possible, and shift accumulator features are readily available.

**Notes:**

1. These test results should be of interest to the electronics industry, specifically to designers and manufacturers of integrated digital logic circuits.
2. Inquiries concerning this innovation may be directed to:

   Technology Utilization Officer
   Langley Research Center
   Langley Station
   Hampton, Virginia, 23365
   Reference: B65-10193

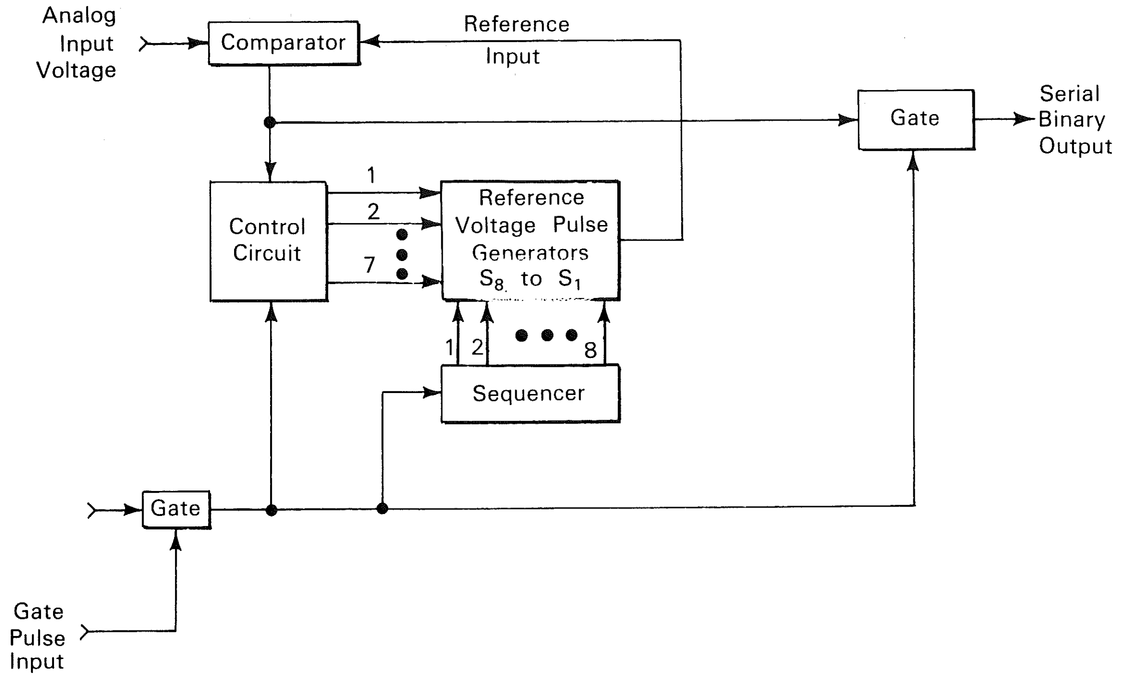
**Patent status:** NASA encourages commercial use of this innovation. No patent action is contemplated.

Source: Charles Husson
(Langley-129)

June 1965 Brief 65-10194

# NASA TECH BRIEF

## Analog-To-Digital Converter Has Increased Reliability and Reduced Power Consumption



**The problem:** Decreasing average power consumption and increasing component reliability in analog-to-digital converter circuits.

**The solution:** An eight-bit analog-to-digital converter, which uses solid-state components in pulse operation to minimize average power consumption and magnetic core components to increase reliability and minimize average power consumption.

**How it's done:** The input gate pulse allows eight 400-cps clock pulses to be applied to the memory control circuit, the sequencer, and the output gate in order to time and control the formation of the binary number. The sequencer triggers the reference pulse generators sequentially from $S_8$ to $S_1$. The output from the reference pulse generators is applied to the comparator, where the amplitude of the reference voltage pulse is compared to the amplitude of the analog voltage input. If the analog voltage amplitude is greater than the reference voltage amplitude, there is no comparator output, a "1" is formed at the binary output, and the memory control circuit triggers that particular reference pulse generator for the remainder of the eight clock pulses. That particular reference output is

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therefore summed with each of the remaining reference pulse outputs as they are sequentially triggered by succeeding clock pulses (i.e., $S_8 + S_7$, $S_8 + S_6, \ldots$ $S_8 + S_1$). A "0" is formed at the binary output when the analog amplitude is less than the reference amplitude and the particular reference generator is not held.

All of the circuits shown on the diagram are pulse type except for the output gate, the comparator, and a flip-flop in the sequencer circuit. The memory control circuit uses a nonlinear core transformer combined with a linear core transformer in a one-shot blocking oscillator circuit. The nonlinear core transformer acts as the memory element, and the blocking oscillator acts as a delay element and places the nonlinear core transformer in the proper state of operation. The reference pulse generators are blocking oscillators using nonlinear transformer cores. The sequencer circuit is similar to a ring counter, in which a single input pulse is transferred from core to core, so that the output of each core is used to trigger a reference pulse generator. The use of magnetic core components increases reliability both through the inherent reliability of magnetic core components, and by reducing the number of components required. Average power consumption is reduced by the use of blocking oscillators, which are in a cutoff state part of the time, instead of flip-flops, which always have one component conducting.

**Notes:**

1. This invention should be of interest to companies that manufacture analog-to-digital converters.
2. Applications of this invention will be limited by its rate of operation requiring 200 microseconds to form one binary word.
3. Inquiries concerning this invention may be directed to:

Technology Utilization Officer
Goddard Space Flight Center
Greenbelt, Maryland, 20771
Reference: B65-10194

**Patent status:** NASA encourages the immediate commercial use of this invention. It is owned by NASA and inquiries about obtaining royalty-free rights for its commercial use may be made to NASA, Code AGP, Washington, D.C., 20546.

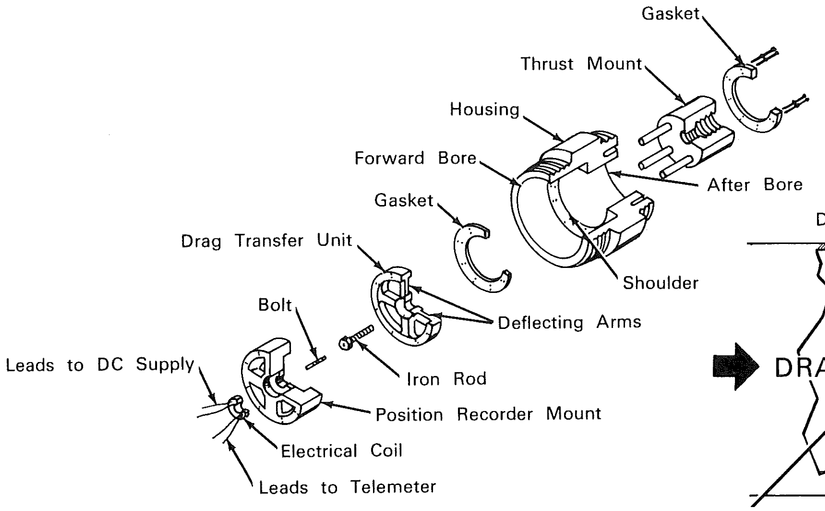
Source: Joseph C. Thornwall
(GSFC-246)

June 1965

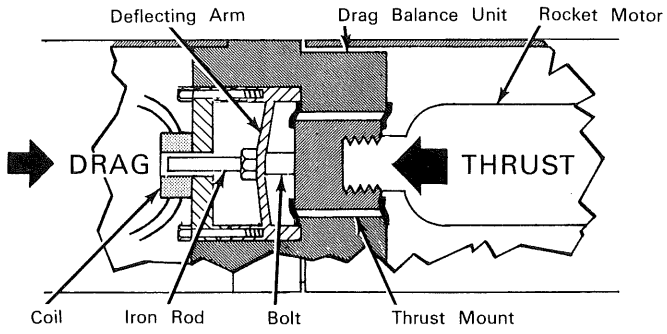
Brief 65-10195

# NASA TECH BRIEF

## Device Measures Fluid Drag on Test Vehicles


Gasket
Thrust Mount
Housing
Forward Bore
After Bore
Gasket
Shoulder
Drag Transfer Unit
Deflecting Arms
Bolt
Iron Rod
Leads to DC Supply
Position Recorder Mount
Electrical Coil
Leads to Telemeter

DRAG BALANCE (EXPLODED VIEW)


Deflecting Arm
Drag Balance Unit
Rocket Motor
DRAG
THRUST
Coil
Iron Rod
Bolt
Thrust Mount

DRAG BALANCE ASSEMBLY IN ROCKET

**The problem:** To measure the aerodynamic drag forces acting on a vehicle, such as a rocket, moving through the atmosphere.

**The solution:** An electromechanical drag balance, integrally mounted inside the test vehicle, that senses the drag forces experienced by the vehicle and telemeters the data to a remote receiving station.

**How it's done:** The drag balance device consists of a cylindrical housing with coaxial bores of two different diameters. The forward bore has a diameter sufficient to carry the loads imposed by the forward end of the vehicle, and the after bore has a smaller diameter so that a shoulder is formed about halfway through the housing. The after bore holds a thrust mount, with space between the inner wall of the bore and the outer wall of the mount for damping fluid. A neoprene gasket at each end of the thrust mount closes the gap between the thrust mount and the after bore. The gaskets are sufficiently flexible to allow relative longitudinal movement between the thrust mount and the after bore. The thrust mount is firmly attached to the forward end of the rocket motor in the test vehicle. A circular drag transfer element, with four equally-spaced radial arms and a diameter slightly less than the forward bore, fits against the shoulder at the housing midsection and is rigidly fixed to the thrust mount by a bolt. A magnetizable rod, such as iron, projects

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from the head of the bolt. A position recorder mount similar in construction to the drag transfer element is joined to the drag transfer element by means of bolts. The after end of the bore of the recorder mount is fitted with an insulated electrical coil that is connected to a dc power supply. The coil has a hollow core with a diameter large enough that the iron rod can pass into it without touching the walls. A telemetry unit is mounted in front of the recorder mount so as to move as a unit with the propulsion system.

In operation, the drag forces imposed on the test vehicle and its integrally mounted drag balance cause the radial arms of the drag transfer unit to deflect, the outer ends bending rearward with respect to the inner ends, so that there is longitudinal relative motion in the forward direction of the thrust mount. As this occurs, the iron rod moves into the electromagnetic field of the coil in the recorder mount, varying the coil inductance and thereby the current flowing through the coil. The variation in coil current is directly proportional to the deflection between the ends of the arms of the drag transfer unit. This variation in coil current may be continuously telemetered to a remote station where it may be recorded using conventional equipment calibrated to measure drag in pounds as a function of time.

**Notes:**

1. This device may also be used for testing the hydrodynamic drag characteristics of underwater vehicles. Its main advantage is that drag data can be obtained rapidly under actual test conditions.
2. Inquiries concerning this invention may be directed to:

   Technology Utilization Officer
   Langley Research Center
   Langley Station
   Hampton, Virginia, 23365
   Reference: B65-10195

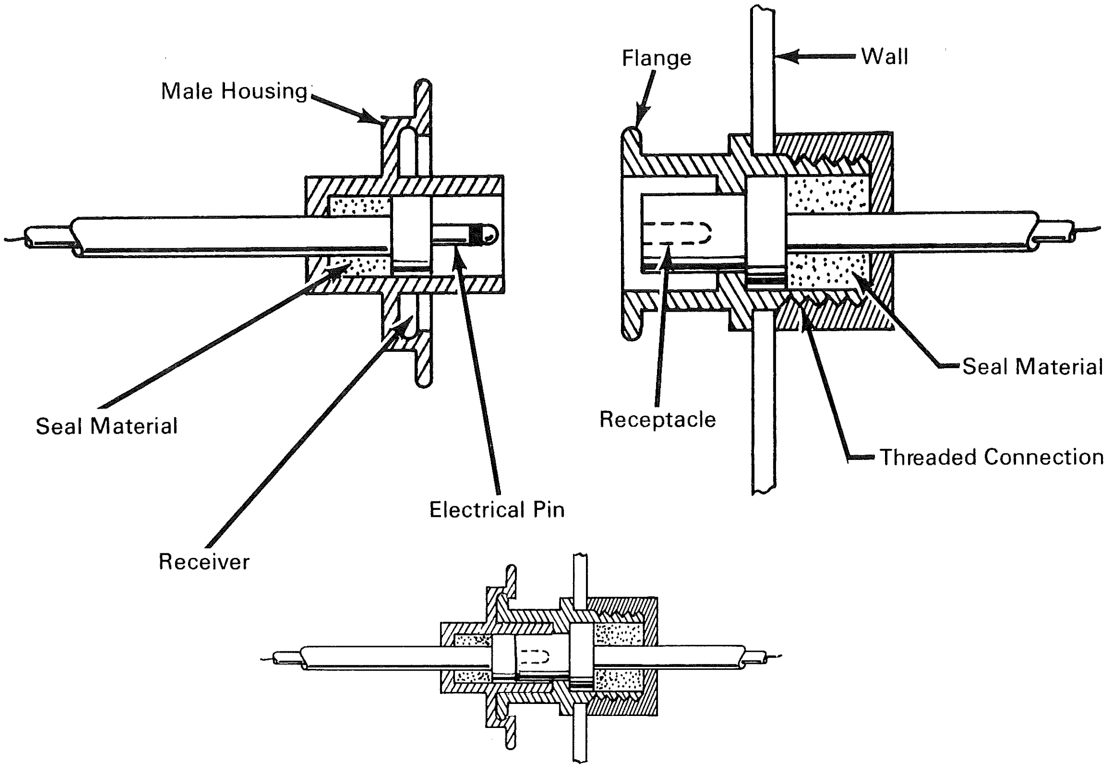
**Patent status:** NASA encourages the commercial use of this invention. It has been patented by NASA (U.S. Patent No. 3,001,395), and royalty-free license rights will be granted for its commercial development. Inquiries about obtaining a license should be addressed to NASA, Code AGP, Washington, D.C., 20546.

Source: Abraham Leiss, Joseph H. Judd,
and Robert Freeman
(Langley-34)

June 1965 Brief 65-10196

# NASA TECH BRIEF

## Inexpensive Electrical Connector Is Moisture and Corrosionproof



**The problem:** Provide an inexpensive, moistureproof electrical connector for use in a corrosive atmosphere. Few electrical pin-type connectors are waterproof, and those such as the lanyard-type connectors that are waterproof are expensive.

**The solution:** A simple compression-sealed connector made principally of plastic components. The simple design and the use of plastic make the connector inexpensive.

**How it's done:** The connector assembly consists of three basic parts, a male housing, a female housing, and a seal cap. The female housing is installed in a support bracket or through a wall by threading it into the seal cap. The cap compresses the seal material to effect a moisturetight closure around the wire entering the female housing. The male housing has an electrical pin that mates with the receptacle in the female housing. As the two housings are engaged, the seal material in the male housing is compressed, sealing the wire

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entering the male housing. The two housings are held together by the action of the flange on the female housing engaging the receiver on the male housing.

**Notes:**

1. This design could be readily modified to provide a multiple-pin connector.
2. When suitable plastic materials are used, this design maintains connector integrity in corrosive environments such as salt spray, chemical atmospheres, etc.
3. Inquiries concerning this invention may be directed to:

Technology Utilization Officer
Manned Spacecraft Center
P.O. Box 1537
Houston, Texas, 77001
Reference: B65-10196

**Patent status:** NASA encourages the immediate commercial use of this invention. Inquiries about obtaining rights for its commercial use may be made to NASA, Code AGP, Washington, D.C., 20546.

Source: North American Aviation, Inc. under contract to Manned Spacecraft Center
(MSC-164)

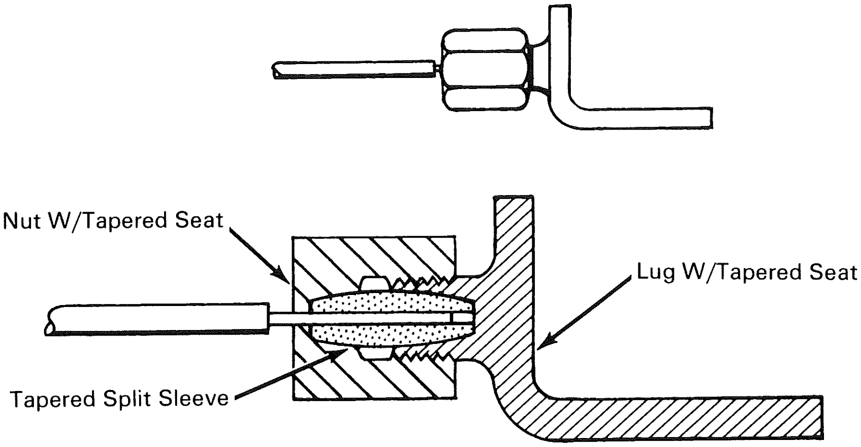
June 1965

Brief 65-10197

# NASA TECH BRIEF

NASA Tech Briefs are issued by the Technology Utilization Division to summarize specific technical innovations derived from the space program. Copies are available to the public from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia, 22151.

## Improved Solderless Connector Is Easily Disconnected



**The problem:** To design a solderless connector that can be easily disconnected and reassembled and that will resist vibration. Commonly used crimped connectors damage conductors upon disassembly.

**The solution:** A compression type connector using a tapered, split sleeve that is tightened by a nut into a mating lug.

**How it's done:** The metal sleeve, which is tapered at both ends, fits over the bare conductor. The nut is threaded only through part of its length. A tapered seat at the base of the nut is formed to receive the sleeve. The lug has a male threaded end and a tapered recess that matches the sleeve. The sleeve fits over the conductor and between the nut and the lug, and is compressed by tightening the nut onto the lug.

**Notes:**

1. The connector can be used in place of standard solder lugs and to connect unsolderable wire, such as tungsten or niobium.
2. Inquiries concerning this innovation may be directed to:

   Technology Utilization Officer
   Jet Propulsion Laboratory
   4800 Oak Grove Drive
   Pasadena, California. 91103
   Reference: B65-10197

**Patent status:** NASA encourages commercial use of this innovation. No patent action is contemplated.

Source: Hughes Aircraft Co. under contract
to Jet Propulsion Laboratory
(JPL-SC-060)

Category No. 01

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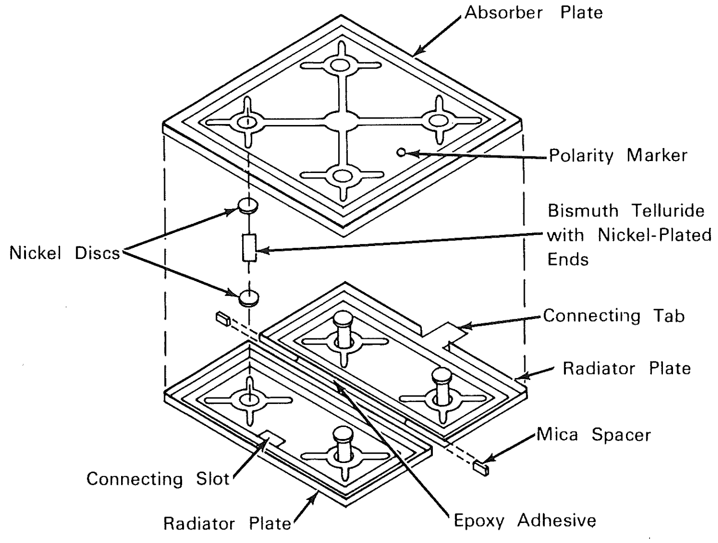
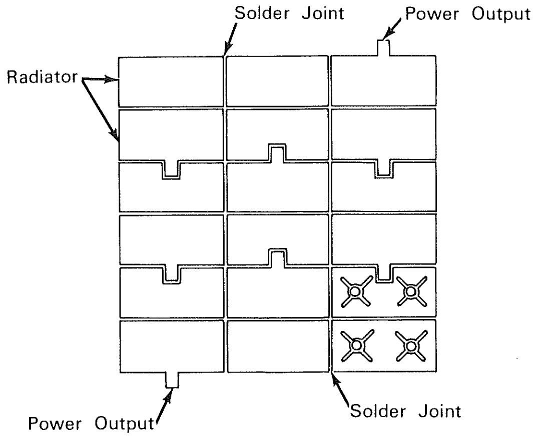
June 1965 Brief 65-10199

# NASA TECH BRIEF

## Modular Thermoelectric Cell Is Easily Packaged in Various Arrays



MODULAR CELL (Exploded View)



3X3 CELL ARRAY (Bottom View)

**The problem:** Designing a solar thermoelectric energy conversion device that can be easily packaged in various arrays to form power supplies having desired voltage and current output characteristics. Previous thermoelectric devices have been limited to arrays of approximately one square foot and constructed as integral strips or sheets providing undesirable low-voltage, high-current characteristics. This large thin-plate design introduces vibration and thermal stress problems in addition to fabrication and replacement difficulties.

**The solution:** A modular thermoelectric cell (approximately 1-inch square and 1/8-inch thick) employing two pairs of thermoelectric elements each pair of which is connected in parallel between two sets of aluminum plates. Any number of these cells can be arrayed to give the required voltage and current outputs at a relatively high efficiency and power-to-weight ratio.

**How it's done:** The absorber plate, made of aluminum, is coated on the top face with solar absorbing optical film. The base of the cell is made of two aluminum plates to provide a series circuit between each pair of electrically parallel thermoelectric elements. The base, which also functions as a radiator, is appropriately coated on the underside to provide for optimum dissipation of unconverted thermal energy. Mica spacers insulate the radiator plates from each other; an epoxy resin cements the plates and spacers together. The four thermoelectric elements consist of bismuth telluride with nickel plated ends which are soldered to nickel discs with a 99.5% lead–0.5% zinc solder. Each of these elements is joined to the aluminum plates with a 95% zinc–5% aluminum solder. A thin mica spacer (not illustrated) insulates the absorber plate from the radiator plates and also adds structural rigidity to the cell assembly. The radiator plates are fabricated with slots and tabs for connection

(continued overleaf)

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of any number of cells in series, parallel, or series-parallel arrays.

## Notes:

1. The modular cells may be easily and economically mass-produced. A variety of materials may be used, depending on the environment in which they are to function.
2. Replacement of defective cells in an array is a simple, inexpensive procedure.
3. These cells should have application as solar-energy conversion devices for terrestrial locations, space power supplies, emergency power supplies in survival kits, and as high-signal-output thermal sensing devices.
4. Inquiries concerning this invention may be directed to:

   Technology Utilization Officer
   Goddard Space Flight Center
   Greenbelt, Maryland. 20771
   Reference: B65-10199

**Patent status:** NASA encourages the immediate commercial use of this invention. It is owned by NASA and inquiries about obtaining royalty-free rights for its commercial use may be made to NASA, Code AGP, Washington, D.C., 20546.

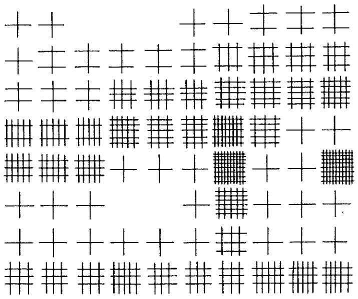
Source: Joseph Epstein
(GSFC-339)

June 1965

Brief 65-10200

# NASA TECH BRIEF

## Density Trace Made with Computer Printout



**The problem:** Although present computer printers can present scientific data in the form of a density trace in which character shading is proportional to data magnitude, they are limited to standard alphameric characters. Because of their nonuniform shapes, the variations in print density are not true representations of data magnitude.

**The solution:** A special drum for a computer-controlled printer provides uniformly shaped characters and evenly spaced variations of print density that precisely reflect data magnitude.

**How it's done:** The special drum is provided with horizontal lines (1, 2, 3, 5, or 8 per character) and vertical lines (1, 3, or 5 per character). These characters may be printed singly or in combination by overprinting. To provide deeper shadings, additional sets of identical characters are provided in an offset mode 1/3 space left, right, up, or down. This results in about 180 different combinations, ranging from minimum density (blank) to maximum, which involves the densest horizontal and vertical characters plus their corresponding 1/3 space offset characters.

**Notes:**

1. Actual order of density may be initially determined by means of a reflectance densitometer which will show the number of evenly spaced combinations required for the data under investigation.
2. Full intensity range may be covered by use of only 20 drum segments if character combinations are efficiently used. Since the standard drum has 64 segments, a full alphameric character set plus several special symbols may be included on the same drum, thereby removing it from a limited specialty category.
3. This invention would be useful in the plotting of temperature profiles, geographical contours, pressure gradients, electric potential gradients, and magnetic field configurations.
4. Inquiries concerning this invention may be directed to:

Technology Utilization Officer
Goddard Space Flight Center
Greenbelt, Maryland, 20771
Reference: B65-10200

**Patent status:** NASA encourages the immediate commercial use of this invention. It is owned by NASA and inquiries about obtaining royalty-free rights for its commercial use may be made to NASA, Code AGP, Washington, D.C., 20546.

Source: Meredith Wilson
(GFSC-322)
Category No. 01

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June 1965 Brief 65-10202

# NASA TECH BRIEF

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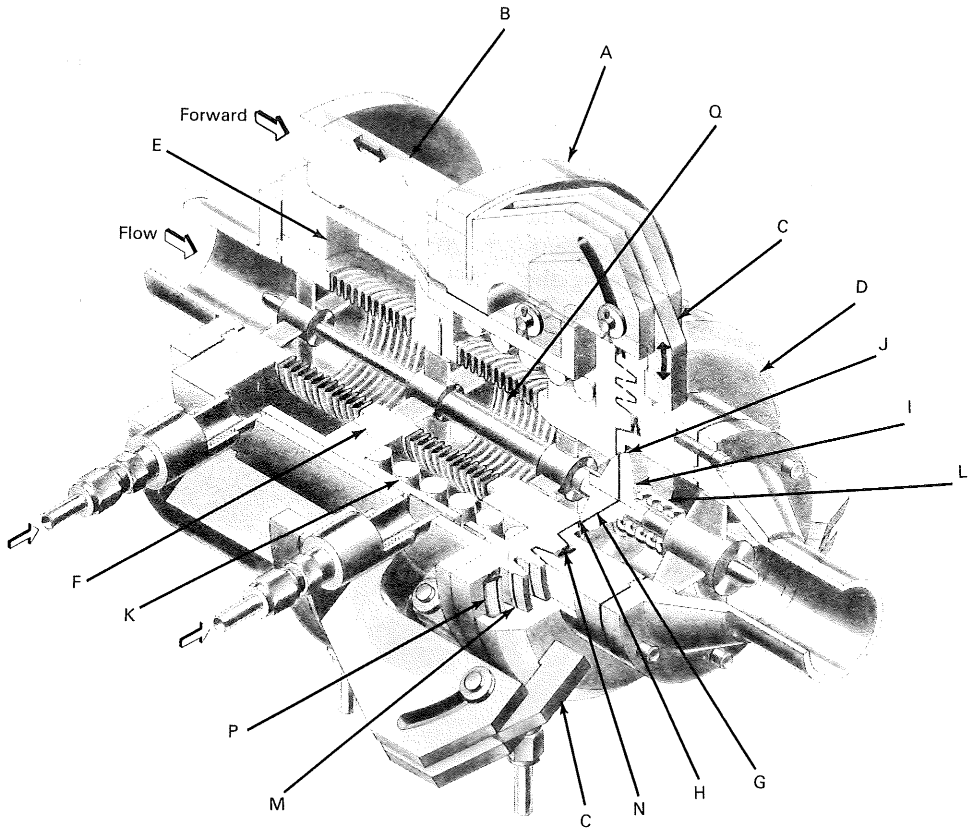
## Quick-Disconnect Coupling Provides Safe Transfer of Hazardous Fluids



**The problem:** To develop a device which allows quick and safe uncoupling of plumbing during ground-to-vehicle transfer of cryogenic fluids and hazardous fluids such as fluorine.

**The solution:** Use a "quick-disconnect" coupling which allows remote positive control of liquid pressure and flow during the transfer operation, remote connection and separation capabilities, and negligible liquid spillage upon disconnection.

**How it's done:** To commence the connection phase, a rearward movement of the driver (A) relative to the ground-half housing (B) spreads the locking fingers (C). Both halves of the coupling are then aligned and mated. Finally, a forward movement of the driver arrangement closes the fingers around the vehicle-half housing (D). To continue positive contact between the halves, it is necessary to maintain the driver in this forward position.

(continued overleaf)

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The coupling valving is opened by introducing pressurized gas into the chamber (E) of the ground half. The force developed moves the concentric slider ring (F) downstream and raises the ground-half trim (G) from its seat (H). As the ground-half trim continues its movement, it bears against the trim (I) of the vehicle half of the coupling and forces it from its seat (J). Both the ground-half loading spring (K) and the vehicle-half loading spring (L) are compressed by the operation, which gives assurance of a positive shutdown in case of a pressurizing gas failure.

During liquid-fluorine transfer through the coupling, external leakage is prevented by a combination of the static labyrinth grip (formed by the intermeshing faces (M) of the two halves) and the inner and outer V-ring seals (N and P). Any cryogenic liquid leakage past the inner seal is allowed to gasify in the cavity between the labyrinth faces and the outer V-ring seal. Because of the orientation of the V-ring seals, any pressure buildup in the cavity could not exceed that of the liquid-fluorine transfer pressure within the flow passage (Q). An excess of the cavity pressure over the transfer pressure would cause leakage in a reverse direction (e.g., back into the fluorine flow passage). The coupling valving is closed by venting the chamber of the ground half and allowing the loading springs in both halves to seal their respective trims. Separation of the two halves of the coupling is accomplished by a rearward movement of the driver to spread the locking fingers and a final rearward movement of the entire ground half.

**Notes:**

1. This coupling could be used in plumbing systems for the transfer of any cryogenic or hazardous fluids such as rocket propellants, and in low pressure (150 psig) gas transfer operations. It can also be used as an "in-line" pressure and flow control valve.
2. Inquiries concerning this invention may be directed to:

Technology Utilization Officer
Lewis Research Center
21000 Brookpark Road
Cleveland, Ohio, 44135
Reference: B65-10202

**Patent status:** NASA encourages the commercial use of this invention. It has been patented by NASA (U.S. Patent No. 3,170,486), and royalty-free license rights will be granted for its commercial development. Inquiries about obtaining a license should be addressed to NASA, Code AGP, Washington, D.C., 20546.

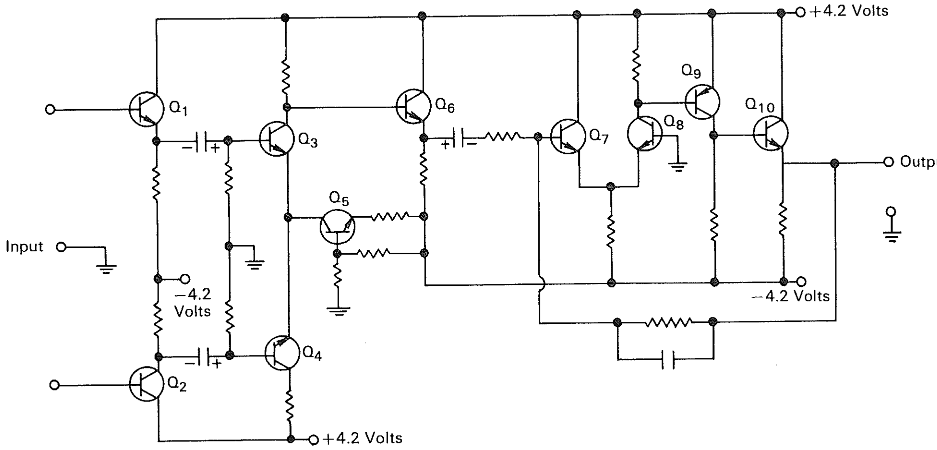
Source: Richard L. Dewitt and Harold W. Schmidt
(Lewis-125)

July 1965

Brief 65-10203

# NASA TECH BRIEF

## Tiny Biomedical Amplifier Combines High Performance, Low Power Drain



**The problem:** To facilitate biomedical studies on mobile subjects, develop a miniaturized, high-performance, high-reliability, battery-operated, solid-state amplifier of low power consumption, that is suitable for both general biomedical use and space research. Amplifiers meeting the requirements of physiological research are available commercially, but they are often too bulky and require too much power for many applications. Small amplifiers have been developed but often with compromise of some aspect of performance.

**The solution:** A transistorized, portable, high-performance amplifier that utilizes a differential input to obtain a common-mode rejection of 25,000 to 1. Because of its small size and low power drain it may be mounted directly on an ambulatory subject.

**How it's done:** Transistors $Q_1$ and $Q_2$ are emitter followers and provide the necessary high input impedance of about 10 megohms differential. The differential output of the emitter followers is converted to a single-ended signal by a difference amplifier consisting of $Q_3$, $Q_4$, and $Q_5$. Transistor $Q_5$ provides the difference amplifier with the high emitter impedance necessary for high common-mode rejection. The signal is fed sequentially through an emitter follower $Q_6$, a second difference amplifier $Q_7$ and $Q_8$, a common emitter amplifier $Q_9$, and a final emitter follower $Q_{10}$. Capacitance coupling in these stages is minimized to provide good low frequency response from 0.15 cps. The amplifier exhibits a gain of 1,000 while drawing 5 milliwatts of power.

**Notes:**

1. This amplifier has been constructed in a weld-connected cordwood configuration with dimensions of 2.0 cm by 1.7 cm by 0.9 cm and weighing 4.5 grams.
2. This device should find application in the biomedical field for amplifying electrocardiogram and electromyogram signals.

(continued overleaf)

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3. Inquiries concerning this innovation may be directed to:

Technology Utilization Officer
Ames Research Center
Moffett Field, California, 94035
Reference: B65-10203

**Patent status:** NASA encourages commercial use of this innovation. No patent action is contemplated.

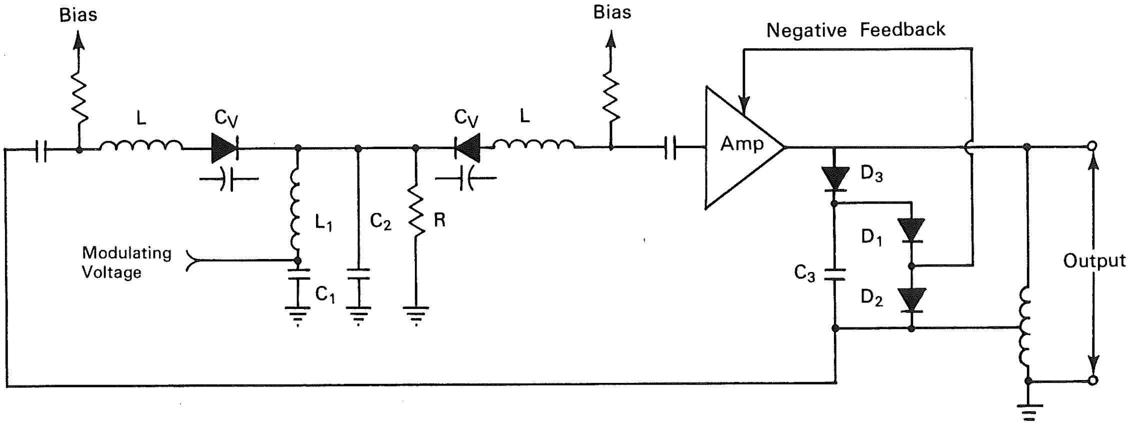
Source: Thomas B. Fryer and
Gordon J. Deboo
(ARC-41)

July 1965.

Brief 65-10204

# NASA TECH BRIEF

## Voltage Variable Oscillator Has High Phase Stability



**The problem:** Although frequency-modulated oscillators are available, their applications are restricted by certain operating limitations. In LC or reactance-tube oscillators relatively low levels of phase stability are normal, and in piezoelectric crystal oscillators, modulation is limited to a fraction of a percent of the center frequency.

**The solution:** A voltage variable oscillator using a low noise, phase stable amplifier with negative feedback, plus two (or more) series resonant LC circuits for high phase stability and optimum frequency deviation.

**How it's done:** The resonant part of the oscillator consists of two identical series resonant circuits, each consisting of an inductor (L) and a voltage variable capacitance ($C_V$) loosely coupled by capacitor $C_2$. Since $C_V$ is a voltage variable capacitance, the oscillator frequency can be varied by applying a modulating voltage. A low-pass filter section, consisting of $C_1$, $L_1$, and $C_2$, is used to isolate the RF oscillator signal from the modulating signal. The filter load resistor R has a resistance much greater than the capacitive reactance of $C_2$ at the oscillation frequency.

Amplifier negative feedback is accomplished by the network consisting of $C_3$, $D_1$, $D_2$, and $D_3$. A dc voltage proportional to the oscillator output voltage is developed across $D_3$ and $C_3$ and applied to the high-frequency point contact diodes $D_1$ and $D_2$. If the amplifier output tends to increase, the higher output signal reduces the dynamic resistance of $D_1$ and $D_2$ and negative feedback to the amplifier increases to maintain a constant output signal level.

**Note:** Inquiries concerning this invention may be directed to:

Technology Utilization Officer
Langley Research Center
Langley Station
Hampton, Virginia, 23365
Reference: B65-10204

**Patent status:** NASA encourages the immediate commercial use of this invention. It is owned by NASA and inquiries about obtaining royalty-free rights for its commercial use may be made to NASA, Code AGP, Washington, D.C., 20546.

Source: Chase P. Hearn
(Langley-123)

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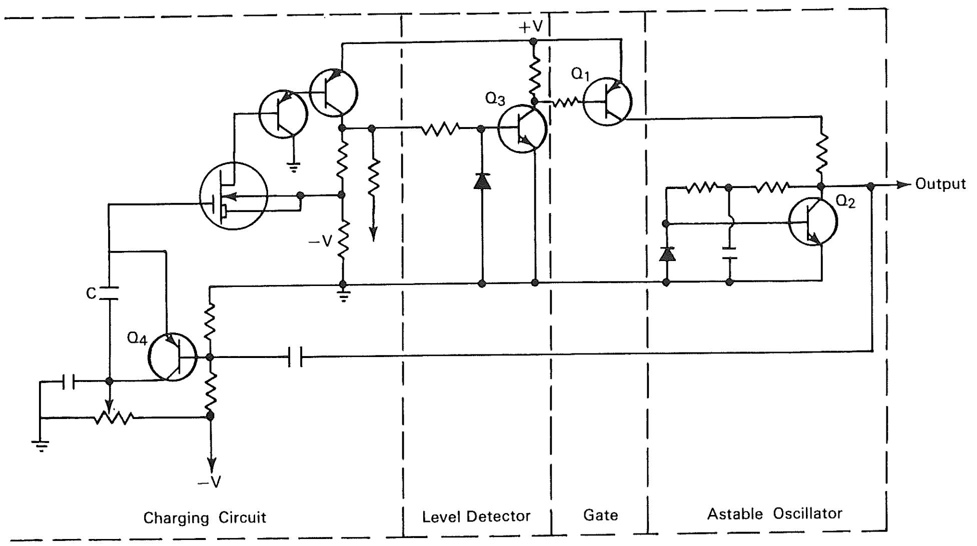
July 1965 Brief 65-10206

# NASA TECH BRIEF

## Sensitive Electrometer Features Digital Output



**The problem:** To design an electrometer that will measure very low currents ($10^{-6}$ to $10^{-12}$ amperes) and produce a digital output linearly related to the magnitude of the input.

**The solution:** A four-stage, transistorized electrometer consisting of a charging circuit, a level detector, a gate, and an astable oscillator, plus a feedback loop to reset the charging circuit.

**How it's done:** The gate transistor $Q_1$ is normally not conducting and prevents the positive supply from being applied to the astable oscillator $Q_2$. The astable oscillator, therefore, generates no output. When an input current is applied to the circuit, capacitor C starts to charge. When the charge on C reaches some predetermined level, the level detector $Q_3$ is triggered. The level detector turns the gate $Q_1$ on and a positive voltage is applied to $Q_2$, which generates an output pulse. The trailing edge of this pulse is fed back to $Q_4$, which turns on and discharges C, returning it to zero charge level. The level detector $Q_3$ is no longer energized and the gate $Q_1$ turns off. This process is repeated, producing a series of pulses from the oscillator $Q_2$. Because the time required for C to charge depends on the magnitude of the input current, the frequency of the output pulses from $Q_2$ is a direct indication of input current magnitude.

**Notes:**

1. This circuit eliminates the need for a logarithmic compression network, a temperamental feature of prior circuits.
2. This electrometer will permit advantage to be taken of the capabilities of state-of-the-art sensors in very low current ranges ($10^{-6}$ to $10^{-12}$ amperes).

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Previously, data at levels $10^{-10}$ amperes or lower have been lost.

3. Inquiries concerning this invention may be directed to:

   Technology Utilization Officer
   Goddard Space Flight Center
   Greenbelt, Maryland, 20771
   Reference: B65-10206

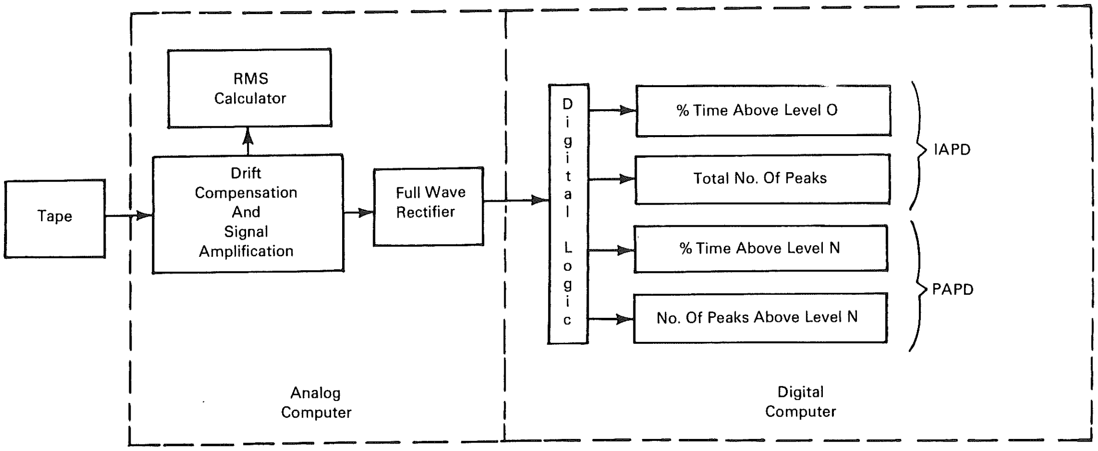
**Patent status:** NASA encourages the immediate commercial use of this invention. Inquiries about obtaining rights for its commercial use may be made to NASA, Code AGP, Washington, D.C., 20546.

Source: Henry Doong
(GSFC-288)

July 1965 Brief 65-10208

# NASA TECH BRIEF

## Hybrid Computer Technique Yields Random Signal Probability Distributions



**The problem:** A complete space vehicle responds, during launch, to a variety of loadings, the study of which requires the outputs of many sensors. Analyzing these data graphically by hand introduces delays and human error factors. A rapid, accurate determination of probability distributions from the sensor outputs is needed.

**The solution:** A special digital logic computer is combined with a standard analog computer to determine the probability distributions of both the instantaneous and peak amplitudes of a random signal recorded on magnetic tape.

**How it's done:** The instantaneous amplitude probability distribution (IAPD) of a random signal is the percentage of time the signal is above some arbitrary value, where there are n arbitrary values to provide the distribution comparison. The peak amplitude probability distribution (PAPD) of a random signal is the percentage of the total number of peaks that are above some arbitrary value where there are n arbitrary values.

The recorded signal from the tape is amplified and fed to a low pass filter, whose output is inverted and subtracted from the input signal to remove the low frequency components identified with drift in the sensing and recording devices. The RMS calculator continuously generates the root-mean-square of this information signal. The RMS signal is rectified and routed to the digital logic where the two components (IAPD and PAPD) are determined and fed to the readout. To measure the percentage of time the signal is above some arbitrary value (IAPD), it is assumed that the signal exceeded that level 100% of the time, and the amount of time the signal was below that level is subtracted. This is accomplished by dividing the logic time base into 10,000 equal increments and subtracting one digit for each time increment the signal is below that level. When the time base counter reaches

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0000, it produces a carryout that stops the computer and feeds the answer to the readout.

To measure the percentage of the total number of peaks that are above some arbitrary value (PAPD), comparator outputs drive one-way digital differentiators. A one-way differentiator produces a blip one clock pulse wide when the input goes from the low level to the high level (goes from 0 to 1). The differentiator output drives a binary upcounter. When the input to the counter is high, it will count up one bit at each clock pulse. Since the differentiator is high for only one clock pulse, the counter will add one bit each time the increasing signal crosses the set level. The signal, rather than the absolute value, drives the counter in level 0. This assures that the signal will pass through zero. The counter in level 0 counts only half the total peaks because the negative portion of the signal has no effect on the comparator.

**Notes:**

1. Data that requires five to seven man-days to reduce by hand can be reduced in 30 seconds by this method.
2. This method of analysis should have application in such nonstationary random processes as system characteristics in structural, electrical, atomic energy, or biomedical fields.
3. Inquiries concerning this invention may be directed to:

Technology Utilization Officer
Ames Research Center
Moffett Field, California, 94035
Reference: B65-10208

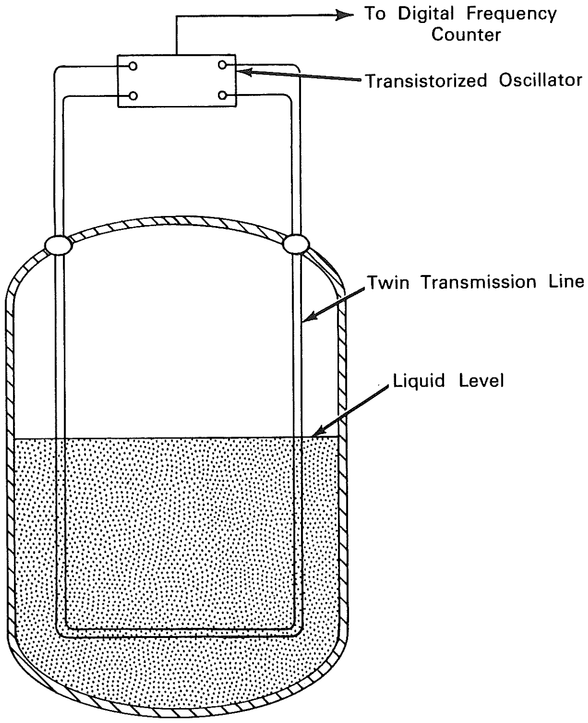
**Patent status:** NASA encourages the immediate commercial use of this invention. Inquiries about obtaining rights for its commercial use may be made to NASA, Code AGP, Washington, D.C., 20546.

Source: William D. Cameron
(ARC-34)

July 1965 Brief 65-10209

# NASA TECH BRIEF

## Oscillator Circuit Measures Liquid Level in Tanks



**The problem:** Accurately measuring the level of a liquid in a tank by electronic means. The measurement system must operate automatically without moving parts and provide an output signal of liquid level that can be transmitted to a remote recorder.

**The solution:** An oscillator circuit employing a twin transmission line as a liquid level probe.

**How it's done:** A continuous loop of twin transmission line extending through the liquid in the tank is connected to a transistorized 5-mc oscillator. The oscillation frequency of this resonant circuit for a liquid of given dielectric constant is directly proportional to the level (depth) of liquid in the tank. Since the system losses are only a few db in this relatively low-frequency system, the oscillation frequency is almost totally determined by line length rather than transistor characteristics, resulting in excellent frequency stability. A conventional 10-mc digital counter connected to the oscillator circuit is used to provide a readout of the oscillation frequency, which in turn is a direct measure of the liquid level.

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**Notes:**

1. The separation between the two legs of the loop must be at least ten times the spacing between the twin conductors comprising the line in order to minimize coupling effects.
2. Instead of using a continuous loop of twin transmission line, one leg of line terminated in an open circuit at the bottom of the tank may be used. This arrangement, however, may produce large errors because of signal reflections from the surface of the liquid and the tank bottom.
3. Inquiries concerning this invention may be directed to:

Technology Utilization Officer
Marshall Space Flight Center
Huntsville, Alabama, 35812
Reference: B65-10209

**Patent status:** NASA encourages the immediate use of this invention. Inquiries about obtaining rights for its commercial use may be made to NASA, Code AGP, Washington, D.C., 20546.

Source: International Business Machines under contract to Marshall Space Flight Center
(M-FS-245)

July 1965

Brief 65-10212

# NASA TECH BRIEF

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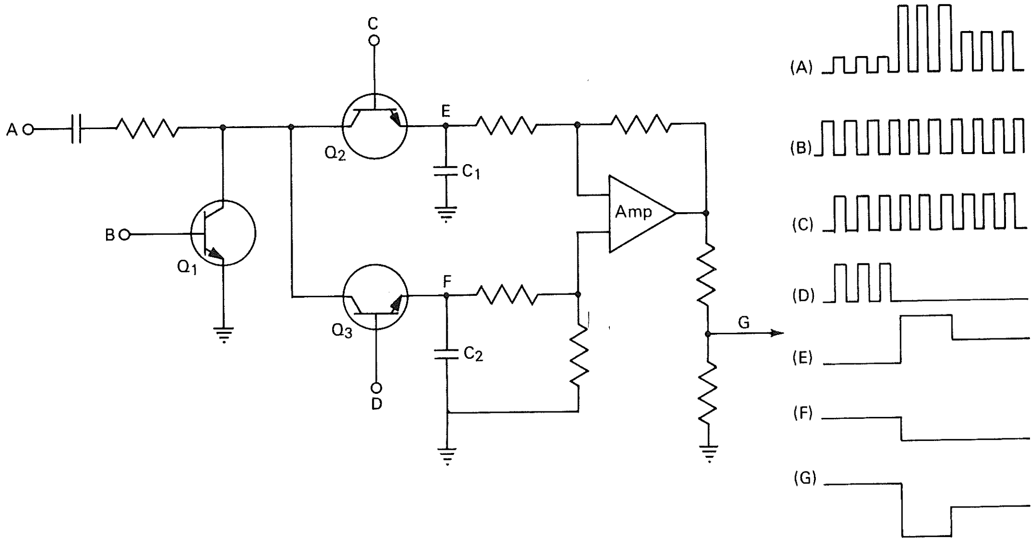
## Detector Circuit Compensates for Vidicon Beam Current Variations



**The problem:** Temperature excursions in vidicons (television camera tubes) result in dark current variations that cause black level shifts. These shifts must be compensated for if the video output is to be a true representation of what the vidicon "sees".

**The solution:** Design of the detector circuit so that it clamps the video signal to the dark current component of the signal. This is accomplished in the detector circuit since the information pulses must first be detected to obtain the video envelope for transmission.

**How it's done:** The video pulse signals (A) from the video amplifier are supplied to the detector circuit input. Video clamping pulses (B) gate $Q_1$ on when video information is present, establishing a zero reference level for the incoming video and eliminating background noise between pulses. Video gate pulses (C) gate $Q_2$ on when video is present, and dark current gate pulses (D) gate $Q_3$ on when the dark current component is present. The video signal is detected by the charge and discharge of $C_1$, and the dark current component is detected by the charge and discharge of $C_2$. The video envelope (E) is applied to the inverting input of the differential amplifier and the dark signal envelope (F) is applied to the noninverting input. The common-mode rejection characteristics of the differential amplifier cancel the dark current component, thus clamping the video signal at the level of the dark current component (G). Because black level shifts occur as a function of variations in the dark current component level, dark current cancellation will compensate for these shifts.

**Notes:**

1. This innovation could be used in other repetitive pulse systems to compensate for background noise variations or transducer bias fluctuations.

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2. This technique for black level compensation is applicable to most video systems.
3. Inquiries concerning this innovation may be directed to:

Technology Utilization Officer
Goddard Space Flight Center
Greenbelt, Maryland, 20771
Reference: B65-10212

**Patent status**: NASA encourages commercial use of this innovation. No patent action is contemplated.

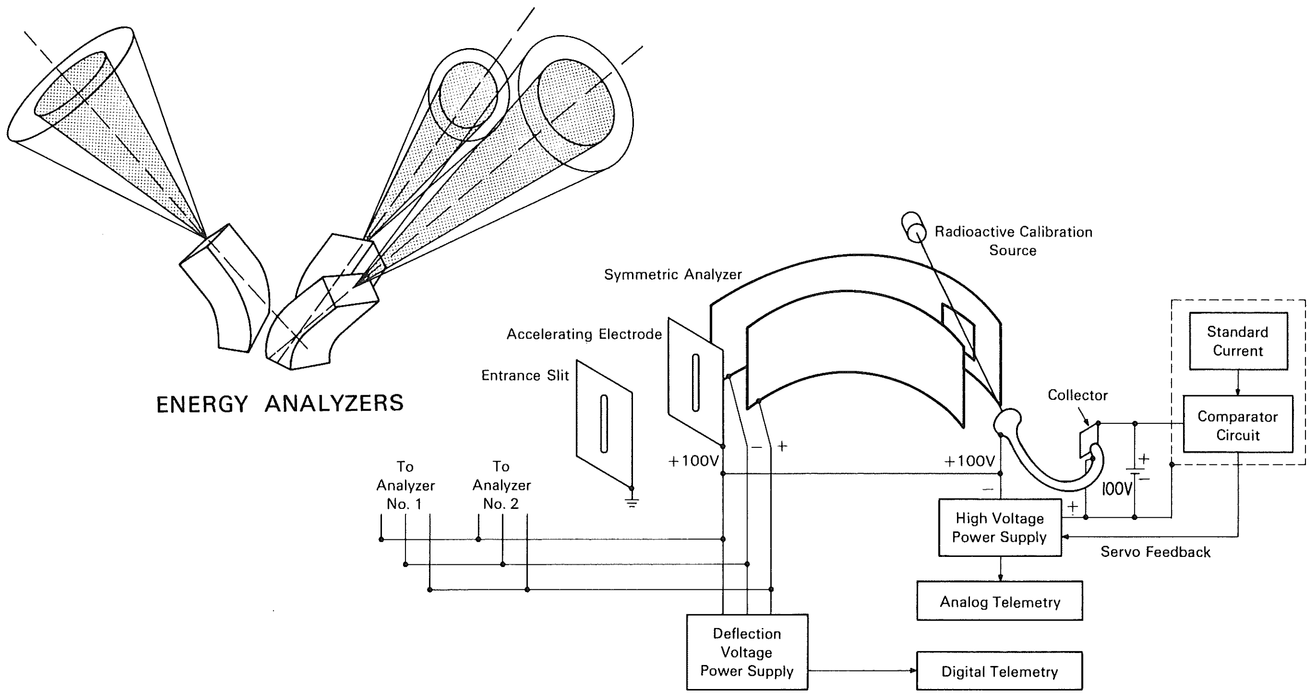
Source: Radio Corporation of America
under contract to
Goddard Space Flight Center
(GSFC-310)

July 1965 Brief 65-10213

# NASA TECH BRIEF

NASA Tech Briefs are issued by the Technology Utilization Division to summarize specific technical innovations derived from the space program. Copies are available to the public from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia, 22151.

## Multiaxial Analyzer Detects Low-Energy Electrons


Radioactive Calibration Source
Symmetric Analyzer
Accelerating Electrode
Entrance Slit
Collector
Standard Current
Comparator Circuit
To Analyzer No. 1
To Analyzer No. 2
+100V
– +
+100V
–
+
100V
+
–
High Voltage Power Supply
Servo Feedback
Analog Telemetry
Deflection Voltage Power Supply
Digital Telemetry

ENERGY ANALYZERS

SYSTEM DIAGRAM

**The problem:** To provide a method for detecting and measuring the intensity and direction of flow of electrons between zero and 10 kev. Although useful studies of electrons can be made with a wide angle device such as a Faraday cup, measurements made simultaneously in several directions can offer distinct advantages.

**The solution:** A system of three curved plate energy analyzers coupled with three electron multiplier tubes that is stepped uniformly through the energy interval by a common analyzer supply voltage.

**How it's done:** The three energy analyzers and electron multiplier tubes are arranged to measure electron flux in several directions simultaneously. Each detection system is completely independent except for the common stepping supply for the energy analyzers.

As voltage applied to the energy analyzers is increased in steps, higher energy electrons will be able to complete the circular path to the multiplier tubes. Current output from the multiplier tubes passes to the comparator circuit where it is compared with a standard current. Because the output current from the multiplier tubes increases with the number of electrons

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entering and because the gain of the tubes decreases with applied potential, electron flux at each energy level is determined by the change in applied potential required to maintain constant output current. The multiplier tubes are, therefore, operated as null detectors and a fraction of the potential applied to them is transmitted as a measure of electron flux. This provides a dynamic range of five orders of magnitude, and an approximate logarithmic compression of the scale of flux. This instrument will operate in any vacuum system with a pressure below $10^{-5}$mm of mercury.

**Notes:**

1. This invention should be of interest to organizations dealing with low-energy electron flux related to ionospheric physics, explosion physics, nuclear devices, and auroral studies.
2. Inquiries concerning this invention may be directed to:

   Technology Utilization Officer
   Goddard Space Flight Center
   Greenbelt, Maryland, 20771
   Reference: B65-10213

**Patent status:** NASA encourages the immediate commercial use of this invention. Inquiries about obtaining rights for its commercial use may be made to NASA, Code AGP, Washington, D.C., 20546.

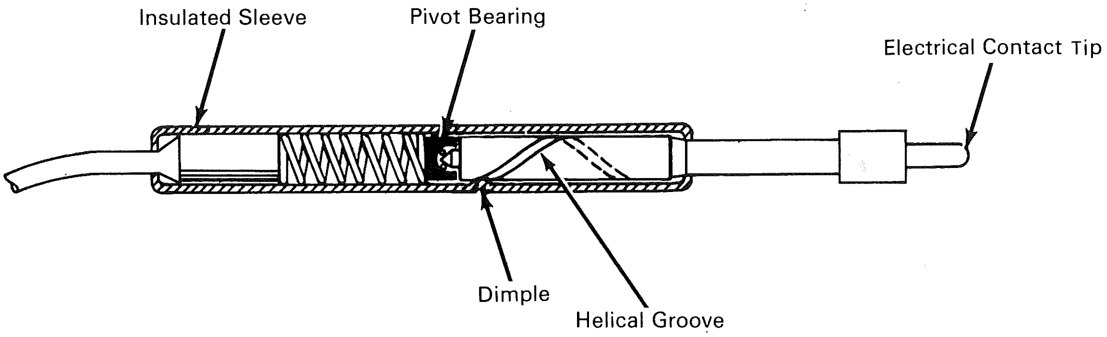
Source: Keith W. Ogilvie,
Don L. Lind, and
Thomas D. Wilkerson
(GSFC-329)

July 1965 Brief 65-10215

# NASA TECH BRIEF

NASA Tech Briefs are issued by the Technology Utilization Division to summarize specific technical innovations derived from the space program. Copies are available to the public from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia, 22151.

## Electrical Probe Ensures Reliable Contact in Socket



**The problem:** To design a probe or pin connector that will make a reliable electrical contact when it is inserted in a mating socket.

**The solution:** A spring-loaded probe that forces the tip of the pin connector to make a wiping contact when it is inserted into the socket.

**How it's done:** One end of the connector pin is seated in the spring-loaded pivot bearing contained in the cylindrical sleeve. A dimple on the inside surface of the sleeve mates with the helical groove around the pin. When the tip of the pin is engaged in a socket and pressure is applied at the opposite end of the probe, the pin is forced to rotate and thereby produce a circular wiping action at the tip.

**Note:** Inquiries concerning this invention may be directed to:

Technology Utilization Officer
Marshall Space Flight Center
Huntsville, Alabama, 35812
Reference: B65-10215

**Patent status:** NASA encourages the immediate commercial use of this invention. It is owned by NASA and inquiries about obtaining royalty-free rights for its commercial use may be made to NASA, Code AGP, Washington, D.C., 20546.

Source: International Business Machines
under contract to Marshall
Space Flight Center (M-FS-315)
Category No. 01

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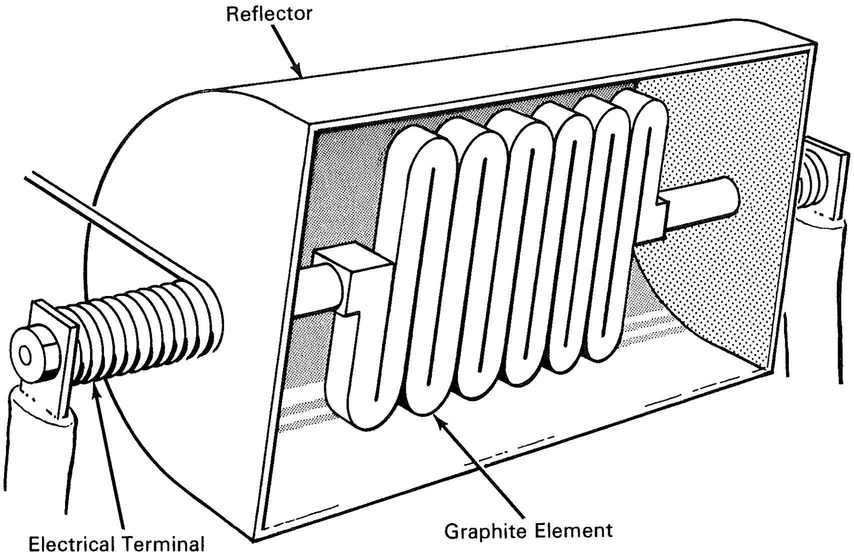
July 1965 Brief 65-10218

# NASA TECH BRIEF

## Graphite Element Serves as Radiant Heat Source



**The problem:** To design a radiant heat source that provides higher heat fluxes and longer operational life than commonly used quartz infrared lamps.

**The solution:** A radiator machined from a graphite block to form a serpentine-type heating element.

**How it's done:** The radiant heat source is a 6-inch square graphite, serpentine-type heating element partially enclosed in a water-cooled metal reflector of gold-plated copper. Electrical terminals on either side of the reflecting enclosure are connected to a 40 kVA welding transformer that supplies the power. A radiation pyrometer behind the reflector monitors the radiator temperature.

**Notes:**

1. This radiator can provide energy to a blackbody receiver in a range of 10 to 80 Btu/ft$^2$-second, within a tolerance of ±2 Btu.
2. The device has a long operational life compared to the quartz lamps, for example, more than 7 minutes at 30 Btu/ft$^2$-second.
3. This innovation would be useful in laboratories testing thermal resistance of materials.
4. Inquiries concerning this innovation may be directed to:

Technology Utilization Officer
Marshall Space Flight Center
Huntsville, Alabama, 35812
Reference: B65-10218

**Patent status:** NASA encourages commercial use of this innovation. No patent action is contemplated.

Source: M-P&VE-M Laboratory
(M-FS-105)
Category No. 01

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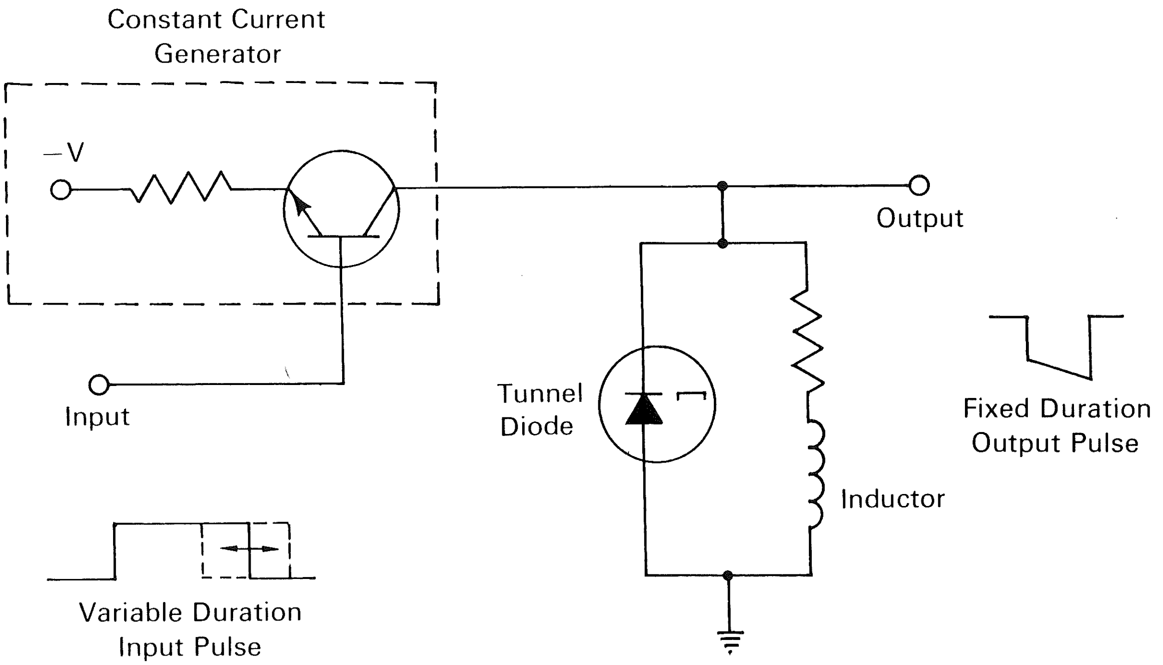
August 1965

Brief 65-10228

NASA TECH BRIEF

NASA Tech Briefs are issued by the Technology Utilization Division to summarize specific technical innovations derived from the space program. Copies are available to the public from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia, 22151.

# Simple Circuit Produces High-Speed, Fixed Duration Pulses


Constant Current Generator
−V
Output
Input
Tunnel Diode
Fixed Duration Output Pulse
Inductor
Variable Duration Input Pulse

**The problem:** To generate an output pulse of fixed duration from a variable duration input pulse ranging from 50 to several hundred nanoseconds. Prior art differentiated the input pulse to obtain a trigger pulse to be applied to a monostable or blocking oscillator. This method requires complex circuitry that consumes a relatively large amount of power.

**The solution:** A circuit consisting of a tunnel diode in parallel with an inductance driven by a constant-current generator. Input pulses of variable width in the nanosecond range yield output pulses of fixed width.

**How it's done:** The variable duration pulse applied to the input of the constant-current generator allows a current to flow through the parallel network. When this current is first applied to the parallel network, the initial high impedance of the inductor causes the entire current to flow through the tunnel diode. This current is adjusted to be greater than the peak current of the tunnel diode, causing the tunnel diode to switch to its high-voltage state. Current through the inductor, initially zero, increases with time and the tunnel diode current and voltage decrease until the valley point of the tunnel diode is reached, causing it to switch to its low-voltage state. Because the inductor now has a relatively low impedance, the output voltage will be approximately zero for the duration of the input pulse.

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**Notes:**

1. Close control of output pulse width is easily accomplished by varying the value of the inductor.
2. This circuit should be of interest to designers of computer and pulsed communications equipment.
3. Inquiries concerning this invention may be directed to:

   Technology Utilization Officer
   Goddard Space Flight Center
   Greenbelt, Maryland, 20771
   Reference: B65-10228

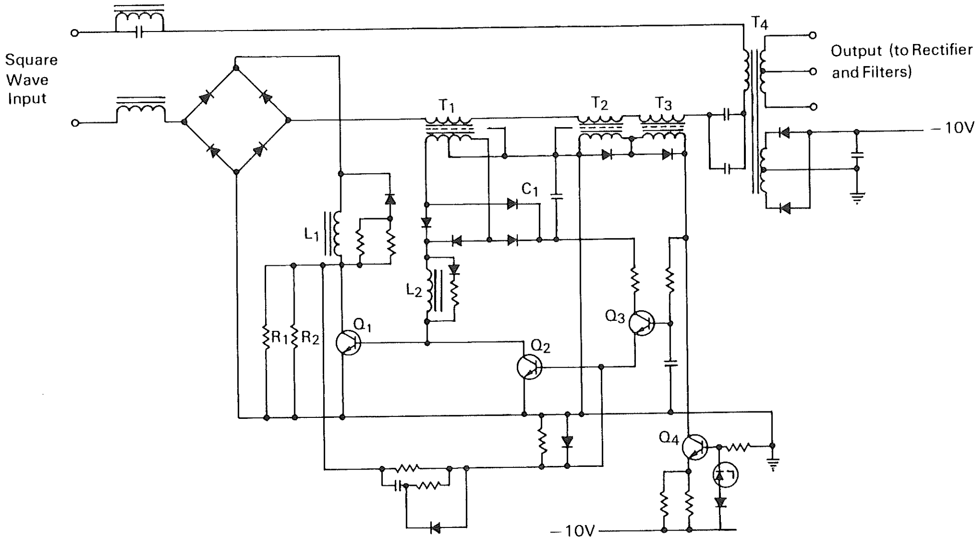
**Patent status:** NASA encourages the immediate commercial use of this invention. Inquiries about obtaining rights for its commercial use may be made to NASA, Code AGP, Washington, D.C., 20546.

Source: Norman M. Garrahan
(GSFC-285)

August 1965 Brief 65-10233

# NASA TECH BRIEF

## High-Speed Square-Wave Current Limiter Operates Efficiently



**The problem:** To design a circuit that will operate efficiently at high speed to limit the current from a square-wave ac power supply to a predetermined value.

**The solution:** A transistorized current limiter in which the transistors operate as switches, resetting after each half cycle of the square wave and thus minimizing power losses.

**How it's done:** During normal operation when limiting is necessary only for momentary loads, such as square-wave switching transients, the diode bridge directs the input through filter $L_1$ and transistor $Q_1$. Filter $L_1$ acts to limit current transients in the square-wave input much as a series inductor does in a dc line. Transistor $Q_1$ operates as a switch, and is normally saturated by current transformer $T_1$ through filter $L_2$. Current transformer $T_1$ also provides collector voltage for transistor $Q_3$ by charging capacitor $C_1$ with transient voltage spikes.

Transformers $T_2$ and $T_3$ are square-loop current transformers which are normally saturated in opposite directions by bias current from transistor $Q_4$. During a particular half cycle, one of the transformers will be driven out of saturation. If the current is sufficiently high, it will overcome transistor $Q_4$ bias current and saturate transistor $Q_3$. Transistor $Q_3$ drives transistor $Q_2$ into saturation which, in turn, cuts off transistor $Q_1$ and directs the square-wave input through current-limiting resistors $R_1$ and $R_2$. At the end of the half cycle, the reversal of the square-wave input causes transistor $Q_2$ to turn off, allowing transistor $Q_1$ to saturate again. The high impedance of resistors $R_1$ and $R_2$ is shunted out and line current is allowed to

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increase until it reaches the predetermined peak whereupon the limiting process repeats. In this way, the current is limited on an instantaneous basis to a predetermined value without producing high losses when the load is normal.

The $-10$ volt reference to transistor $Q_4$ is obtained from a winding on output transformer $T_4$ so that the bias current applied to transformers $T_2$ and $T_3$, which determines the limiting current, is a function of the output transformer voltage. An extremely heavy load on the power transformer will cause current limitation even if the instantaneous current is below the normal limiting value.

**Notes:**

1. An important feature of this invention is that no high power dissipation transistors are required, the operation being such that overheating and possible damage of transistors handling the main line current are avoided.
2. Inquiries concerning this invention may be directed to

Technology Utilization Officer
Jet Propulsion Laboratory
4800 Oak Grove Drive
Pasadena, California, 91103
Reference: B65-10233

**Patent status:** NASA encourages the immediate commercial use of this invention. Inquiries about obtaining rights for its commercial use may be made to NASA, Code AGP, Washington, D.C., 20546.

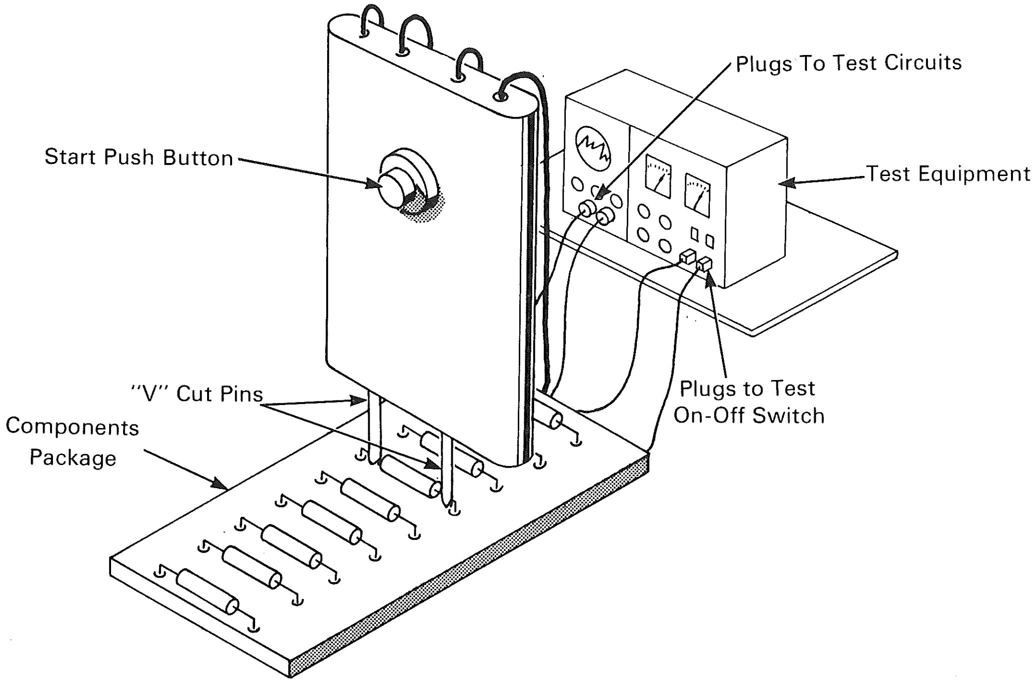
Source: Labko Scientific, Inc.
under contract to
Jet Propulsion Laboratory
(JPL-SC-073)

August 1965

Brief 65-10243

# NASA TECH BRIEF

## Novel Probe Simplifies Electronic Component Testing



**The problem:** Testing of electronic components in volume has been a time consuming task involving unpackaging and repackaging for coded storage according to test results. Handling of small, sensitive components also results in a certain percent that must be discarded due to damage to leads, seals, etc.

**The solution:** A test probe that can be used in conjunction with standard equipment to test axial-lead components in their original packages.

**How it's done:** The test probe consists of a plastic case that holds two metal test pins, two leads to the test equipment circuits, two leads to the test equipment on-off switch, and a start button. The two metal test pins have v-shaped slots filed in their ends to receive the two axial leads of the component. The test probe is pushed against the two leads of the component (still in the original package) and the operator depresses the start button to begin the testing sequence. When the test sequence is completed, the operator moves the probe to the next component in the package and repeats the operation.

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**Notes:**

1. The test probe could readily be modified to test any type of electronic component with automatic or nonautomatic equipment.
2. With this device, a shipment of 17,000 diodes was tested, cataloged, and stored in six working days. Experience shows that at least three additional weeks would have been needed using the old method of unpackaging, testing, and repackaging.
3. Inquiries concerning this invention may be directed to:

Technology Utilization Officer
Goddard Space Flight Center
Greenbelt, Maryland, 20771
Reference: B65-10243

**Patent status:** NASA encourages the immediate commercial use of this invention. Inquiries about obtaining rights for its commercial use may be made to NASA, Code AGP, Washington, D.C., 20546.

Source: Warren F. Syner
(GSFC-342)

August 1965 Brief 65-10244

# NASA TECH BRIEF

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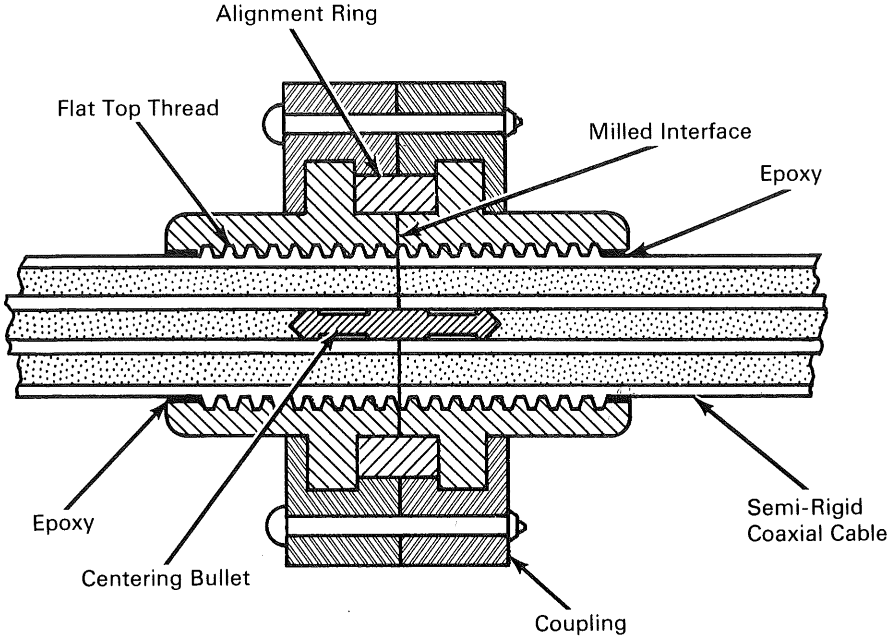
## Lightweight Coaxial Cable Connector Reduces Signal Loss



**The problem:** To design a connector, for flexible, semirigid, and rigid rf coaxial cables, that eliminates the possibility of secondary-emission discharge and provides low signal loss, low VSWR, lightweight construction, and good protection of the cable ends.

**The solution:** A connector with milled interface surfaces that provide near perfect electrical contact, plus alignment and centering components to assure proper joint concentricity.

**How it's done:** The milled interface ensures an almost perfectly smooth electrical contact, free of discontinuities and high or low spots. Because there is essentially no air gap, the contact is free of secondary-emission discharge, which, if sufficiently high, can result in short circuit and breakdown of the cable. The modified threads engaging the outer conductor provide a gap between conductor and connector body for sealing and locking the threads with an epoxy. Precisely concentric alignment of the inner conductor is assured by a centering bullet, and of the outer conductor by a precision alignment ring. A standard, flanged coupling holds the connector together.

**Notes:**

1. This invention should be of interest to designers of communications systems.

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2. Inquiries concerning this invention may be directed to:

   Technology Utilization Officer
   Jet Propulsion Laboratory
   4800 Oak Grove Drive
   Pasadena, California, 91103
   Reference: B65-10244

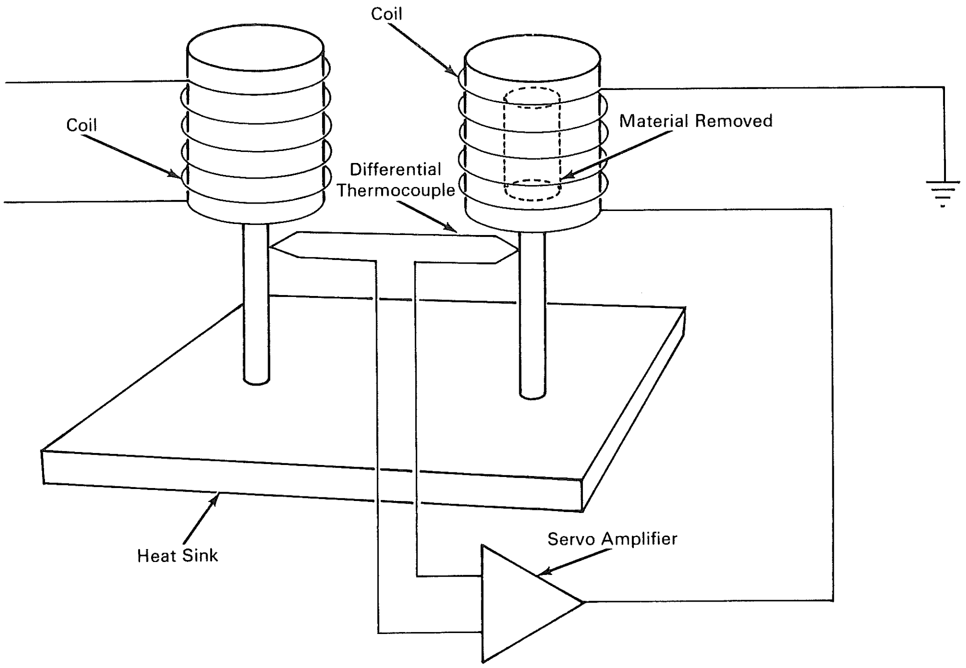
**Patent status:** NASA encourages the immediate commercial use of this invention. Inquiries about obtaining rights for its commercial use may be made to NASA, Code AGP, Washington, D.C., 20546.

Source: Albert G. Brejcha, Jr.
(JPL-720)

August 1965 Brief 65-10247

# NASA TECH BRIEF

## Servo Calorimeter Measures Material Heating Rate



**The problem:** To measure the heating rate of a material when exposed to nuclear radiation. Accurate measurements are complicated by the nonlinear behavior of the specific heat and thermal conductivity of metals with changing temperature.

**The solution:** A servo calorimeter in which the electrical power used is a direct measure of the nuclear heating rate.

**How it's done:** The material to be tested is made up into two rods of identical external dimensions mounted to a heat sink. The rod at the right of the illustration has a finite amount of material removed from it. Identical electrical resistive heating coils are wound around each rod. The coil on the left rod is not electrically connected, but is used to equalize the temperature rise of the right-hand rod due to the mass of its coil.

Upon irradiation, the right-hand rod because of its lower mass, undergoes a smaller temperature rise than the left-hand rod. A differential thermocouple senses the temperature difference between the rods and, through a servo amplifier drives the heating coil on the right-hand rod until the temperatures of the two rods are equal. The nuclear heating range of the material is equal to the servo power delivered to the coil, divided by the rod weight difference.

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**Notes:**

1. The measured heating rate is independent of the specific heat and thermal conductivity of the material.
2. While this method is conceptual and has not been reduced to use, it is theoretically sound.
3. Inquiries concerning this innovation may be directed to:

   Technology Utilization Officer
   AEC–NASA Space Nuclear Propulsion Office
   U.S. Atomic Energy Commission
   Washington, D.C., 20545
   Reference: B65-10247

**Patent status:** NASA encourages commercial use of this innovation. No patent action is contemplated.

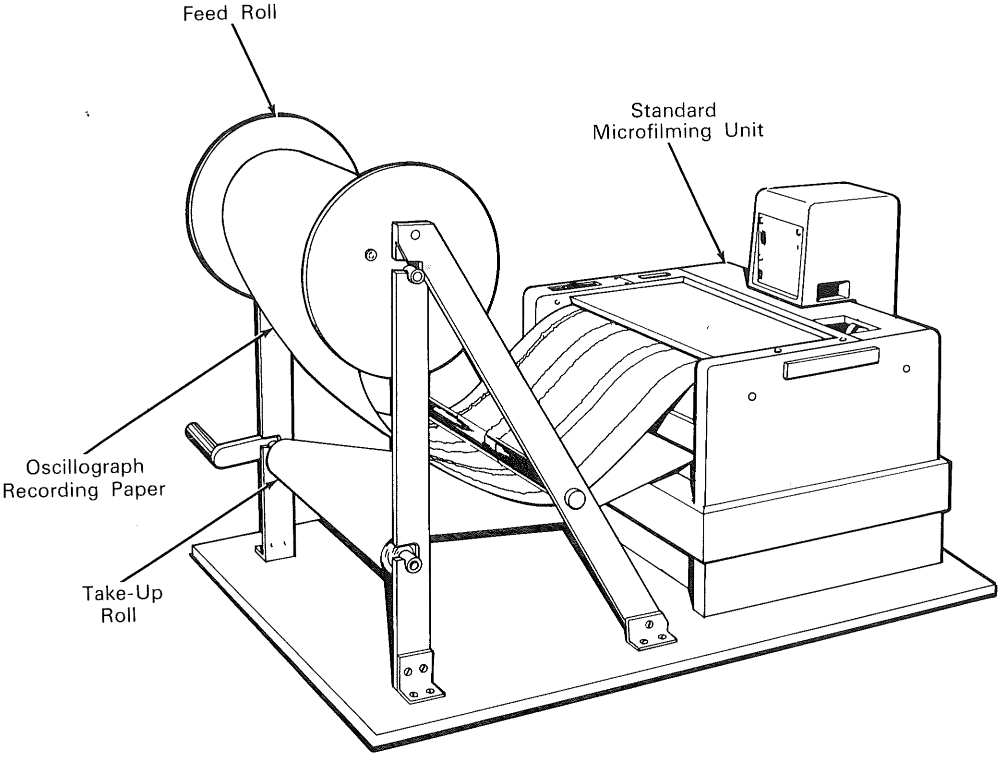
Source: G. Gilmour and J.H. Wilson of
Westinghouse Astronuclear Laboratories
under contract to
Space Nuclear Propulsion Office
(NU-0024)

August 1965

Brief 65-10249

# NASA TECH BRIEF

## Manual-Feed Adapter Permits Microfilming of Continuous Oscillograph Output



**The problem:** During the course of a single nuclear reactor test run, 10 miles of oscillograph recording paper were used to record instrumentation data. Two "manageable" copies of these data were required to be produced at the lowest possible cost.

**The solution:** A manual-feed adapter used in conjunction with a standard microfilm recording unit.

**How it's done:** The simple, hand-cranked adapter is mounted adjacent to the microfilm recording unit and the oscillograph recording paper is fed continuously. Two thousand feet of the oscillograph paper is handled per feed roll and microfilmed at a rate of 70 feet per minute.

**Notes:**

1. This method reduced the 10 miles of records to 26 100-foot rolls of 16-mm film.
2. If necessary the microfilm, or any portion, can be enlarged and printed full size; however, viewing with a standard microfilm reader gives excellent results.

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3. Inquiries concerning this innovation may be directed to:

   Technology Utilization Officer
   AEC-NASA Space Nuclear Propulsion Office
   U.S. Atomic Energy Commission
   Washington, D.C., 20545
   Reference: B65-10249

**Patent status:** NASA encourages commercial use of this innovation. No patent action is contemplated by NASA.

Source: J. Bennett of
Westinghouse Astronuclear Laboratory
under contract to
Space Nuclear Propulsion Office
(NU-0029)

August 1965 Brief 65-10255

# NASA TECH BRIEF

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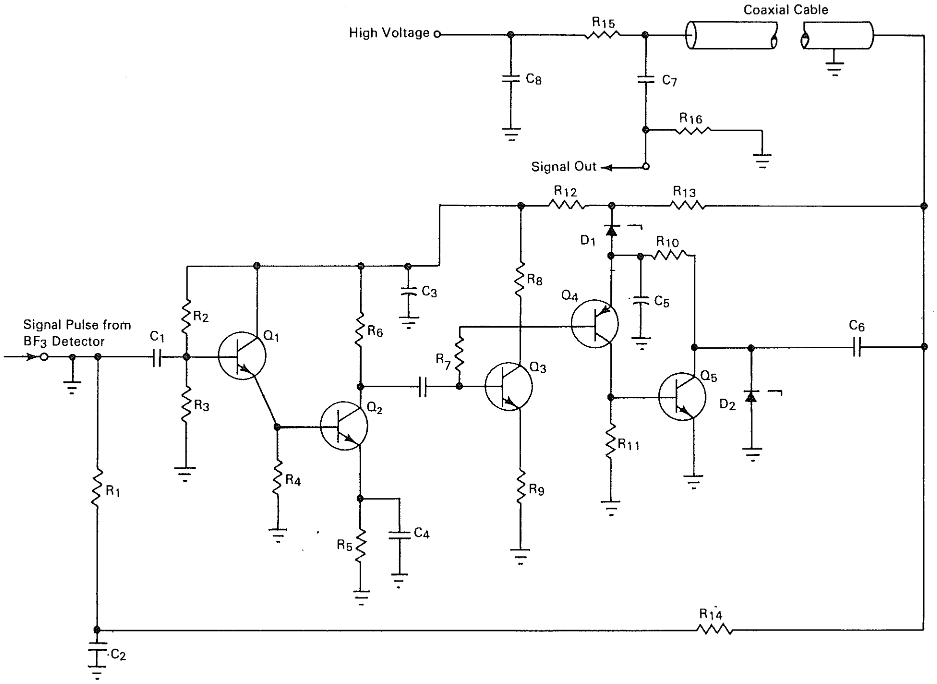
## BF$_3$ Nuclear Detector Preamplifier Uses Single-Cable Connection



**The problem:** In a nuclear particle detector (such as a boron trifluoride neutron detector), it is often advantageous to use a preamplifier in conjunction with the detector tube to improve the signal-to-noise characteristics of the system. The system normally requires three interconnecting cables: one to supply the high voltage to the detector tube; one to supply the preamplifier operating voltage; and one to carry the signal pulse back to the counter. Since long stretches of cable are expensive and troublesome to maintain, a system using one interconnecting cable is desirable. However, a single-cable system must be capable of isolating the preamplifier from the high-voltage supply (which would destroy the elements of the preamplifier).

**The solution:** A preamplifier with isolating and bypass networks permits operation with a single interconnecting cable.

**How it's done:** The signal pulse from the BF$_3$ detector is coupled through capacitor C$_1$ to transistor Q$_1$ in the preamplifier circuit (transistors Q$_1$ through Q$_5$). The detector load resistor R$_1$, capacitor C$_2$, and resistor R$_{14}$ isolate the detector from the high-voltage (1000 to 2500 volts dc) supply, which maintains the preamplifier at an operating level of approximately 15 volts. All ac pulses are removed from the transistor

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supply voltage by capacitors $C_3$ and $C_5$ and resistor $R_{12}$, thus preventing oscillation. Transistor $Q_1$ is an emitter-follower driving transistor $Q_2$, which is a conventional amplifier. Transistors $Q_3$, $Q_4$, and $Q_5$ are dc-coupled amplifier stages. The dc operating voltages and bias are clamped by Zener diode $D_1$ to maintain a very low standby operating current for the preamplifier and yet allow it to deliver the required peak current to the coaxial cable. The high gain and low output impedance of the preamplifier enable it to drive a 75-ohm, 1000-foot cable. The preamplifier output pulses are coupled to the cable by means of capacitor $C_6$. This capacitor initially charges through Zener diode $D_2$ to protect $Q_5$ against current surges. The signal is recovered at the end of the cable by a suitable resistor-capacitor decoupling network ($R_{15}$, $R_{16}$, $C_7$, $C_8$). The value of $R_{15}$ must be equal to the characteristic impedance of the coaxial cable.

**Notes:**

1. The preamplifier, used to amplify the signal pulse from a $BF_3$ neutron detector in order to drive a low-impedance coaxial cable, is characterized by a high output pulse amplitude, good signal-to-noise ratio, and good discrimination against gamma pulses. It is capable of operating at temperatures to 100°C in moderately high gamma-radiation fields.
2. For best operation, the preamplifier should be installed within 1 to 3 inches of the $BF_3$ detector.
3. Inquiries concerning this innovation may be directed to:

   Technology Utilization Officer
   Lewis Research Center
   21000 Brookpark Road
   Cleveland, Ohio, 44135
   Reference: B65-10255

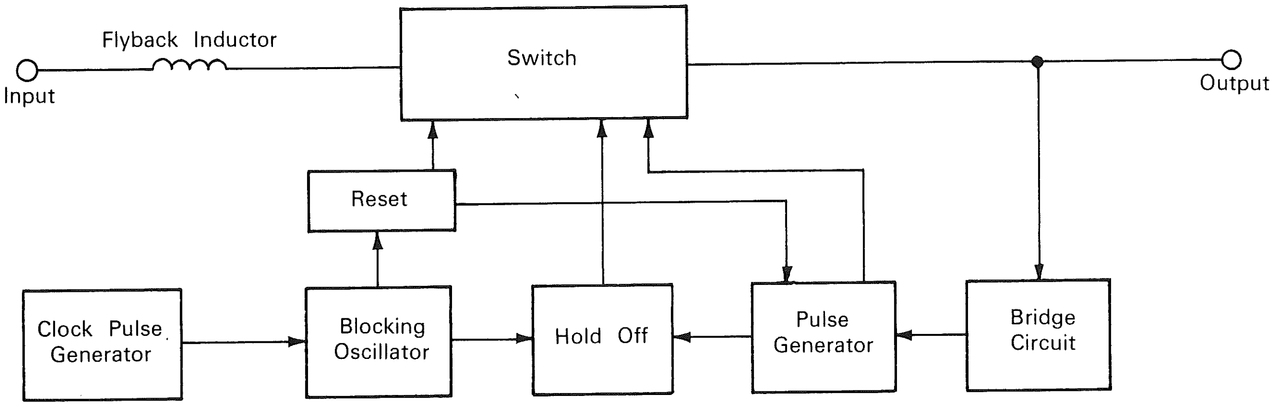
**Patent status:** NASA encourages commercial use of this innovation. No patent action is contemplated.

Source: J. D. Heckelman and R. E. Shumaker
(Lewis-178)

August 1965 Brief 65-10257

# NASA TECH BRIEF

## Inductor Flyback Characteristic Gives Voltage Regulator Fast Response



**The problem:** To provide a regulated dc voltage to varying loads from a dc supply that varies over a wide range. The regulator must be capable of fast response to changes in both load and supply.

**The solution:** A regulator that alternately connects an inductor in parallel and in series with the input voltage source. When connected in parallel energy flowing into the inductor is stored in its magnetic core and, when connected in series, the stored energy is released to the output load at an increased voltage.

**How it's done:** The regulator consists of the flyback inductor, the switch that connects the inductor either in series or parallel with the input, and the associated circuitry that controls the switch.

The clock pulse generator provides the reference signal for the regulator. It produces a constant-frequency square wave at a frequency which is proportional to the regulator supply voltage. Thus, frequency regulation is achieved through supply voltage regulation. The clock pulse generator produces a positive-going square wave at a time when the inductor is in parallel with the unboosted voltage input. The square wave is differentiated and the positive spike fires the blocking oscillator. This activates and controls the reset, and also turns on the hold off. The reset sends a signal to the switch which places the inductor in series with the input. It also sends a signal to the pulse generator to inhibit it. When the inductor is placed in series with the input, a signal to the blocking oscillator turns it off which turns off the reset. At this time the switch attempts to place the inductor back in parallel, but this is prevented by the hold off. When the reset was turned off, a capacitor in the pulse generator began to charge, via the bridge circuit, at a rate inversely proportional to the output voltage. When the capacitor charges to a predetermined value, the pulse generator fires the hold off, removing the hold from the switch and placing the inductor back in parallel with the input. The regulator is now back in its original condition and the process is repeated.

**Notes:**

1. This innovation sould be of general interest in the design of voltage regulators.

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2. Further information concerning this innovation is presented in NASA TN D-2627, "Flyback Voltage Regulator" by Gail D. Smith, February 1965, available from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia, 22151; price $1.00. Inquiries may also be directed to:

   Technology Utilization Officer
   Goddard Space Flight Center
   Greenbelt, Maryland, 20771
   Reference: B65-10257

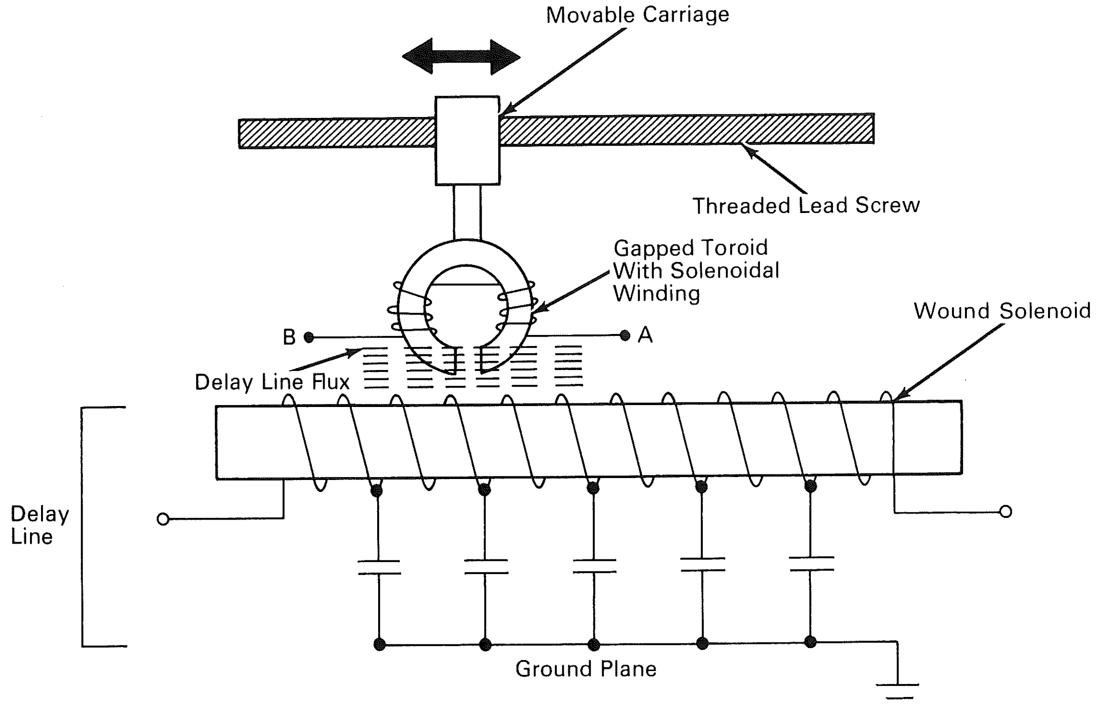
**Patent status**: NASA encourages commercial use of this inovation. No patent action is contemplated by NASA.

Source: (GSFC-361)

August 1965 Brief 65-10258

# NASA TECH BRIEF

## Gapped Toroid Provides Infinite Resolution of Delay-Line Pickup



**The problem:** To provide continuous adjustment (infinite resolution) of the period of a time-delay line. Previous delay lines used a reiterative pie structure with an inductive winding tapped at regular intervals and returned to ground at those points through capacitors. Such a line was adjusted by means of a sliding ohmic contact. With this type of contact, the resolution (the smallest obtainable increment of delay) was determined by the number of turns per unit length of delay line.

**The solution:** The delayed signal is retrieved by means of a gapped toroid magnetically coupled to the delay line. The toroid pickup is moved parallel to the delay line by means of a rotating screw.

**How it's done:** A gapped toroid is mounted on a movable carriage driven by a threaded lead screw. The toroid is positioned so that its gap is normal to the axis of the delay-line solenoid winding. The toroid is not in physical contact with the solenoid.

The toroid winding intercepts magnetic flux from the delay-line solenoid over an area determined by the width of the gap. The output of the toroid winding is obtained through terminals A and B, which are connected to a sliding contact pickup (not shown in illustration).

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The gapped toroid provides infinite resolution of delay because of the continuous nature of the delay-line flux; thus it is superior to previous ohmic contact devices.

**Notes:**

1. This invention should be of interest to manufacturers of signal-detection devices, ranging circuitry, and instrumentation equipment.
2. Inquiries concerning this invention may be directed to:

   Technology Utilization Officer
   Goddard Space Flight Center
   Greenbelt, Maryland, 20771
   Reference: B65-10258

**Patent status:** NASA encourages the immediate commercial use of this invention. Inquiries about obtaining rights for its commercial use may be made to NASA, Code AGP, Washington, D.C., 20546.

Source: George B. Robinson
(GSFC-370)

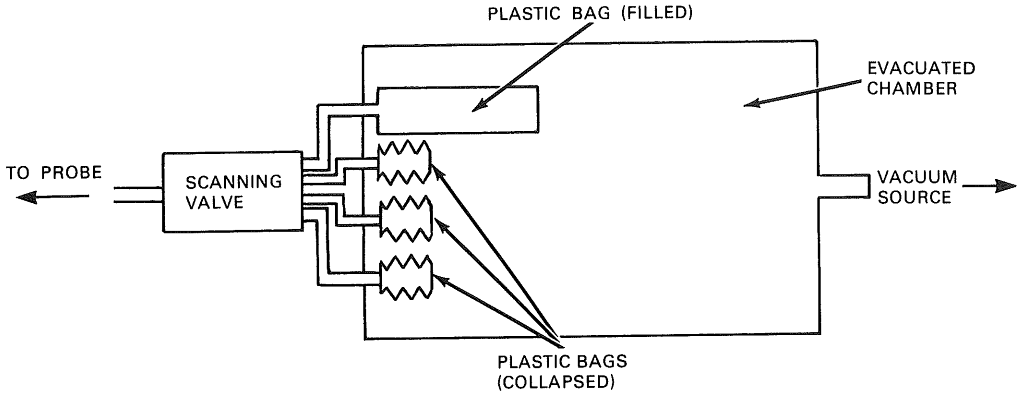
September 1965

Brief 65-10264

# NASA TECH BRIEF

NASA Tech Briefs are issued by the Technology Utilization Division to summarize specific technical innovations derived from the space program. Copies are available to the public from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia, 22151.

## Plastic Bags in Evacuated Chamber Make Lightweight Gas Sampling System



**The problem:** The collection of exhaust gas of an aircraft or space vehicle during flight for use in analyzing system combustion efficiency. Normal ground test systems cannot be applied to flight conditions because of the weight and size of the equipment involved.

**The solution:** A lightweight, portable system that uses an evacuated chamber and plastic bags to collect the exhaust gas in flight for later analysis on the ground.

**How it's done:** Prior to flight, the plastic bags are attached to their inlet ports in the collapsed state and the vacuum chamber and inlet lines are evacuated. The system is connected to the exhaust gas sampling probe and the scanning valve operates to fill the plastic bags sequentially. Impact pressure at the sampling probe entrance is sufficient to drive the gas into the plastic bags during flight. Bags as small as 50 ml in volume at an internal pressure of 4 psia will collect sufficient gas for laboratory analysis.

**Notes:**

1. The chamber could be sufficiently evacuated during flight by a static pressure port on the side of the vehicle.
2. The bags must be of a material that is strong and impervious to hydrogen diffusion.
3. Inquiries concerning this innovation may be directed to:

   Technology Utilization Officer
   Flight Research Center*
   P.O. Box 273
   Edwards, California, 93523
   Reference: B65-10264

**Patent status:** NASA encourages commercial use of this innovation. No patent action is contemplated by NASA.

Source: W. M. Shaffernocker of
General Electric
under contract to
Flight Research Center
(FRC-31)
Category 01

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September 1965 Brief 65-10263

# NASA TECH BRIEF

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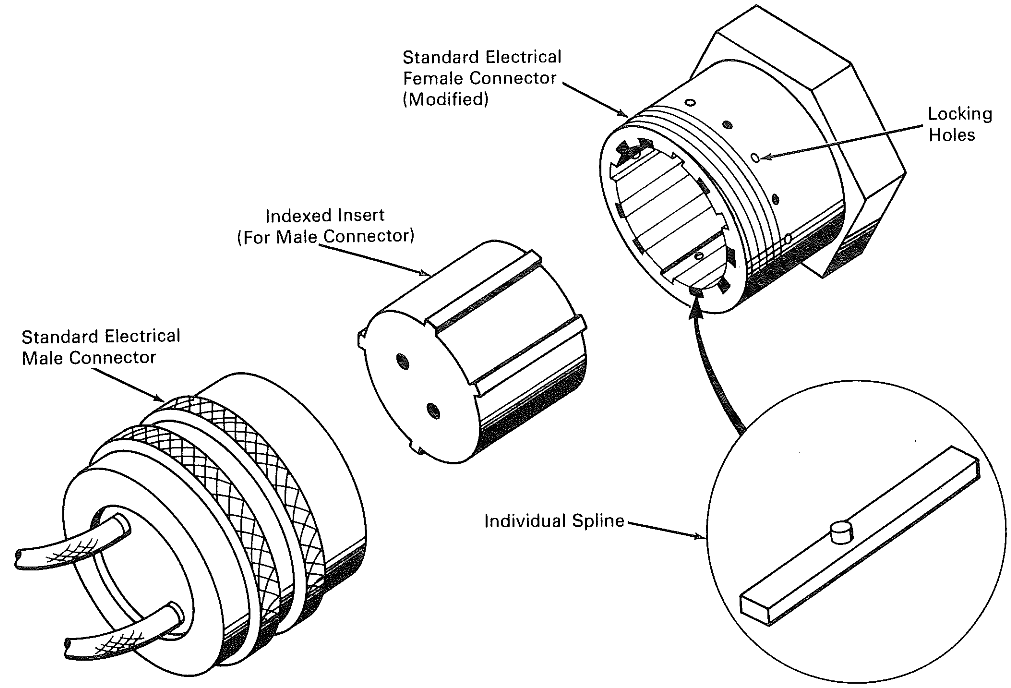
## Indexing Device Ensures Proper Mating of Electrical Connectors


Standard Electrical Female Connector (Modified)
Locking Holes
Indexed Insert (For Male Connector)
Standard Electrical Male Connector
Individual Spline

**The problem:** To eliminate the possibility of incorrectly mating electrical connectors. The mating of male and female connectors to provide the correct matching of connections for various electrical functions is particularly difficult in locations where visibility is obscured.

**The solution:** Use indexing splines with modified standard male and female connectors.

**How it's done:** The female connector is made with uniform grooves extending longitudinally around its inner periphery. During manufacture of the female connectors the indexing splines are press-fitted into each of the connector grooves. One or more of these splines can be easily removed with a punch through the locking holes. Removal of the appropriate splines provides a predetermined pattern of open grooves whereby only mating male connectors having a fixed set of splines arranged in the predetermined pattern can be coupled to the female connectors.

**Notes:**

1. Both male and female connectors with the indexing splines can be inexpensively mass-produced by standard procedures.
2. This innovation makes it unnecessary to stock large quantities of differently indexed connectors, since male and female connectors from a single

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stock can be indexed as desired at the time of installation.

3. Inquiries concerning this invention may be directed to:

   Technology Utilization Officer
   Manned Spacecraft Center
   P. O. Box 1537
   Houston, Texas, 77001
   Reference: B65-10263

**Patent status:** NASA encourages the immediate commercial use of this invention. It is owned by NASA, and a patent application has been filed. When patented, royalty-free nonexclusive licenses for its commercial use will be available. Inquiries concerning license rights should be made to NASA, Code AGP, Washington, D.C., 20546.

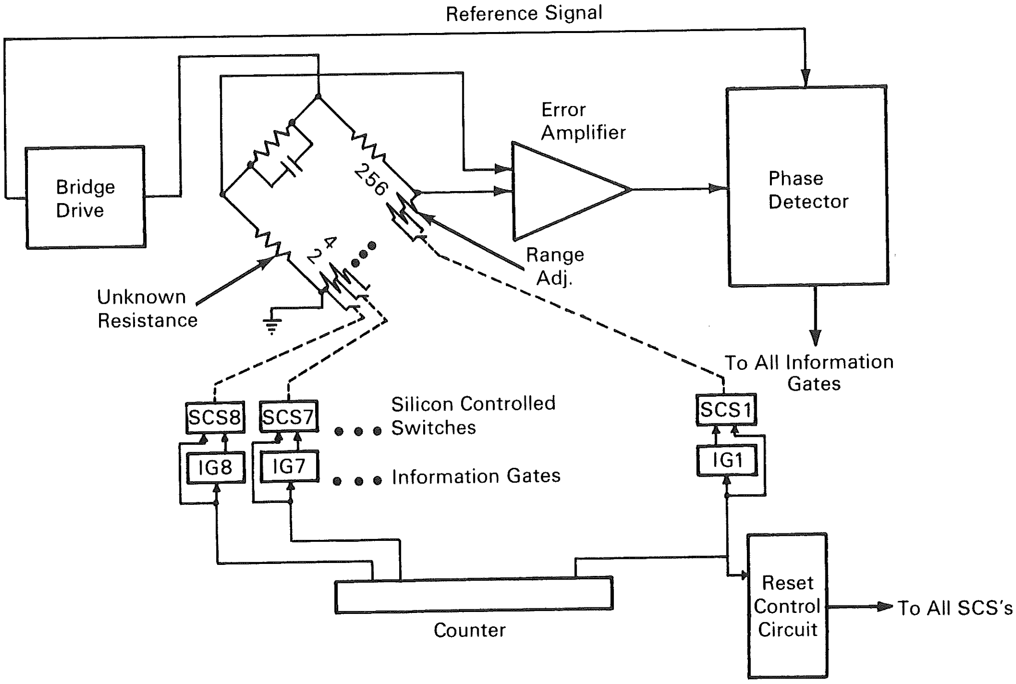
Source: William H. Simmons and
Lyle M. Jenkins
(MSC-155)

September 1965

Brief 65-10274

# NASA TECH BRIEF

## Electronic Ohmmeter Provides Direct Digital Output


Reference Signal
Bridge Drive
Error Amplifier
Phase Detector
256
Range Adj.
4
2
Unknown Resistance
To All Information Gates
SCS8
SCS7
Silicon Controlled Switches
SCS1
IG8
IG7
Information Gates
IG1
Counter
Reset Control Circuit
To All SCS's

**The problem:** Designing an all-electronic digital-readout ohmmeter. Electromechanical ohmmeters with analog-to-digital converters (incorporating servo motors, precision gear boxes, and precision potentiometers) have excess size and weight and are costly to manufacture. In addition, the electromechanical systems have relatively high power requirements and must be used in controlled environments to ensure efficient long-life operation.

**The solution:** A self-balancing Wheatstone bridge circuit in which the unknown resistance (e.g., a platinum wire temperature sensor) comprises one leg, and an automatically adjustable, binary-valued resistance comprises another leg. Automatic adjustment for bridge balancing is achieved by successive approximations.

**How it's done:** The eight resistors in the adjustable leg of the bridge are binary valued (2 ohms, 4 ohms,..., 256 ohms). Each resistance is in parallel with a reed relay contact which, when closed, shorts out the resistance. Initially, all of the contacts are open so that the adjustable resistance assumes its maximum value. A square-wave signal is applied to the bridge from the drive oscillator, so that if the bridge is not balanced an error signal is sent to the error amplifier and on to the phase detector where it is compared with the

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bridge-drive reference signal. The output from the phase detector is sent to all of the information gates ($IG_1$,..., $IG_8$). The combination of the error signal from the phase detector and the output from the counter circuit operates the silicon controlled switch for the largest binary resistor and shorts it out. Depending on the type of error signal then produced, the resistor will either remain shorted out or the switch will open and place it back in the circuit. This type of resistance sampling is then sequentially repeated for the remaining resistors. An output from each silicon controlled switch that indicates the condition of the switch is used for binary readout of the unknown resistance. Reset to place all of the relays in an open position occurs at the start of the sampling pulse for the largest binary resistance.

**Notes:**

1. Higher orders of accuracy can be derived from this circuit by increasing the number of bits and by altering the bridge ratio.
2. A major limitation of this circuit is its relatively low encoding speed. Another limitation is the range of unknown resistances which can be accommodated. The lower limit is set by relay contact resistance and the upper limit by stray capacitance effects.
3. Inquiries concerning this innovation may be directed to:

   Technology Utilization Officer
   Goddard Space Flight Center
   Greenbelt, Maryland, 20771
   Reference: B65-10274

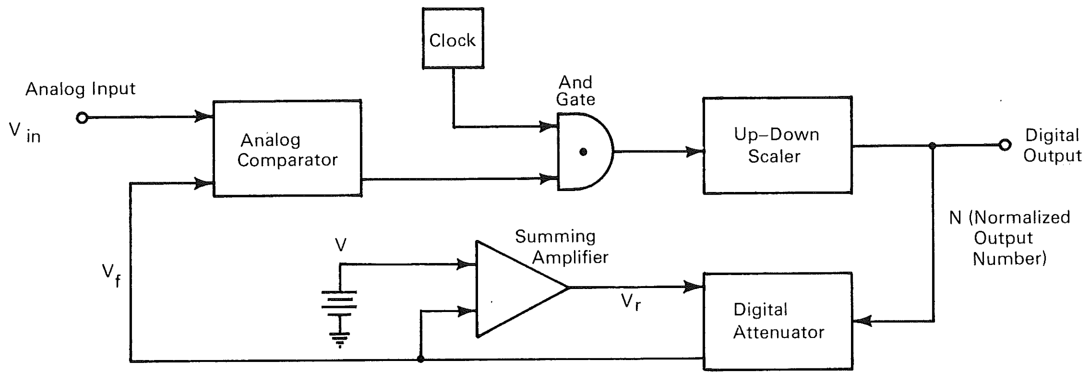
**Patent status**: NASA encourages commercial use of this innovation. No patent action is contemplated.

Source: John Semyan
(GSFC-363)

September 1965 Brief 65-10277

# NASA TECH BRIEF

## Nonlinear Feedback Reduces Analog-to-Digital Converter Error



**The problem:** To design a simple, accurate analog-to-digital converter, (ADC) that exhibits minimum error characteristics. The accuracy of conventional linear ADC's suffers at low operating levels due to their inherent quantization error, i.e., an inability to measure increments smaller then the least significant digit.

**The solution:** A nonlinear analog-to-digital converter that measures the level of an analog input and continuously adjusts the scale sensitivity of the digital readout to attain an effective increase in accuracy. As the output level decreases the scale sensitivity increases to retain a more nearly constant accuracy as expressed in percentage of reading, thus permitting the acquisition of more accurate low-level data.

**How it's done:** In order to obtain the nonlinearity necessary for scale adjustment, an accurate nonlinearity is placed in the conventional feedback path. This is done in the feedback elements consisting of the summing amplifier, reference voltage, and digital attenuator. These elements are capable of a high degree of accuracy as compared to other possible nonlinear elements.

A typical nonlinear analog-to-digital converter consists of six basic subsystems: an analog comparator, a clock and control gate, an up-down scaler, a digital attenuator, a summing amplifier, and a fixed voltage source.

The analog voltage to be sampled is fed into the analog comparator, which produces an output if there is any difference between $V_{in}$ and $V_f$ (the feedback voltage). Any output from the comparator turns the AND gate on and allows the clock signal to be fed to the up-down scaler. The up-down scaler produces the digital output in the form of an output number.

The nonlinear feedback loop consists of the digital attenuator, the summing amplifier, and the fixed voltage supply V. The feedback voltage $V_f$ is proportional to the product of the reference voltage $V_r$ and the normalized digital output N, where N is the ratio of the output number to the number which represents full scale. The summing amplifier adds the fixed voltage V to the feedback voltage and passes the summed

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voltages $V_r$ to the digital attenuator. The attenuator modifies $V_r$ by N, producing a feedback voltage which is a function of itself, a fixed voltage, and the normalized output number.

## Notes:

1. The error characteristics for this nonlinear digital system are superior to those of linear systems. Error expressed in percent of reading is more nearly constant and extension of scale length is possible.
2. The system produces attractive error profiles and can be implemented with only one component (a floating power supply or a summing amplifier) added to a conventional analog-to-digital converter.
3. Variation of the fixed voltage V, or the value of full scale, produces variations in the error profile.
4. Inquiries concerning this invention may be directed to:

   Technology Utilization Officer
   Ames Research Center
   Moffett Field
   Mountain View, California, 94035
   Reference: B65-10277

**Patent status:** NASA encourages the immediate commercial use of this invention. Inquiries about obtaining rights for its commercial use may be made to NASA, Code AGP, Washington, D.C., 20546.

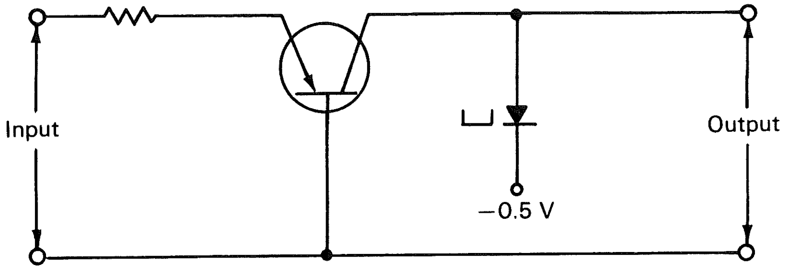
Source: Robert M. Munoz
(ARC-46)

September 1965

Brief 65-10282

# NASA TECH BRIEF

## Constant-Current Regulator Improves Tunnel Diode Threshold-Detector Performance



**The problem:** To design a tunnel diode threshold detector with maximum voltage output and overload protection. In conventional circuits, inputs just at threshold level result in outputs barely large enough to actuate a following stage. Also, as input voltage increases, voltage across and current through the tunnel diode increase. Currents several times as large as the tunnel diode peak current rating will alter its characteristics. These conditions result in marginal or unreliable operation.

**The solution:** A grounded-base transistor placed in the circuit and a bias voltage applied to the tunnel diode. The grounded-base transistor provides a constant current source and yields maximum output voltage for input threshold level. Biasing the tunnel diode limits the voltage across it, thus limiting the current through it to less than its maximum peak current rating.

**How it's done:** The load line for a grounded-base transistor configuration is horizontal; i.e., the collector current is constant with respect to any change in collector-to-base voltage. The −0.5 volt bias applied to the tunnel diode limits the voltage across the diode, thus limiting the current through the diode to less than the maximum peak current rating and preventing tunnel diode characteristic changes.

**Notes:**

1. A diode placed between the base of the transistor and ground would act to compensate for temperature changes in the transistor emitter-to-base voltage.
2. Inquiries concerning this invention may be directed to:

Technology Utilization Officer
Goddard Space Flight Center
Greenbelt, Maryland, 20771
Reference: B65-10282

**Patent status:** NASA encourages the immediate commercial use of this invention. Inquiries about obtaining rights for its commercial use may be made to NASA, Code AGP, Washington, D.C., 20546.

Source: Ciro A. Cancro
(GSFC-239)
Category 01

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September 1965

Brief 65-10281

# NASA TECH BRIEF

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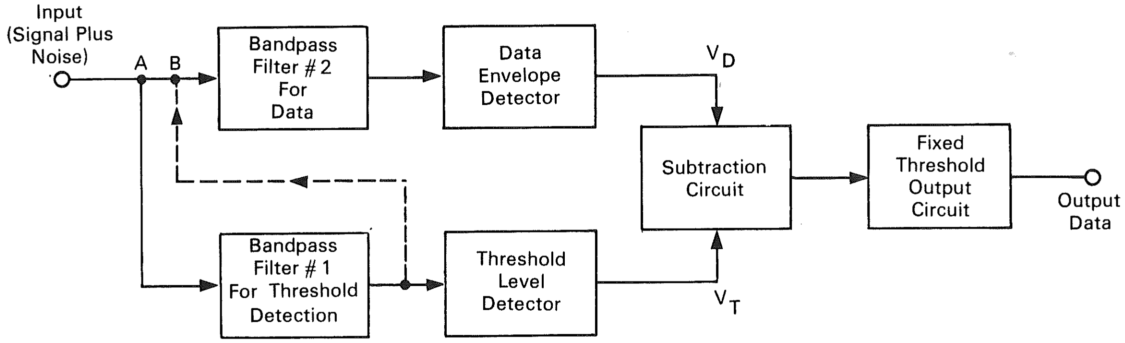
## Circuit Maintains Digital Decision Threshold at Preset Level


Input (Signal Plus Noise)
A
B
Bandpass Filter #2 For Data
Data Envelope Detector
$V_D$
Subtraction Circuit
Fixed Threshold Output Circuit
Output Data
Bandpass Filter #1 For Threshold Detection
Threshold Level Detector
$V_T$

**The problem:** To maintain the optimum decision threshold in digital information link equipment regardless of input-signal and noise-level amplitude variations. Commonly used automatic-gain-control (AGC) circuits are nonlinear in operation, too slow in response for digital system application, and make a receiver quite complex.

**The solution:** An optimum decision-level circuit that will maintain the decision threshold at any preselected percentage of the input-signal amplitude.

**How it's done:** The optimum decision-level circuit consists of a pair of bandpass filters, one detector each for the data envelope and the threshold level, a subtraction circuit, and a fixed-threshold output circuit.

The threshold-level detector detects the peak signal-plus-noise passed by bandpass filter #1. This detector has a fast attack time to provide a threshold voltage to the subtraction circuit before information from the data envelope detector arrives. The voltage decay time of the threshold-level detector is slow relative to the information pulse rate, but fast enough to follow any normal input signal-level variation. The threshold-level detector is variable to provide any desired threshold voltage relative to the amplitude of the data-envelope detector output.

Bandpass filter #2 separates the signal from the noise and feeds it to the data-envelope detector, which recovers the modulation from the carrier and feeds it to the subtraction circuit. The subtraction circuit compares the envelope detector output $V_D$, with the peak voltage $V_T$ of the threshold-level detector. When $V_D$ is greater than $V_T$, the fixed-threshold output circuit produces an output data pulse.

**Notes:**

1. This invention would be useful with communications equipment involving recognition of transmitted digital information.
2. The alternate connection indicated by the dashed line may be desirable when the bandwidth of filter #1 is equal to or greater than that of filter #2. In this case, the line from A to B is omitted.

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3. Inquiries concerning this invention may be directed to:

   Technology Utilization Officer
   Marshall Space Flight Center
   Huntsville, Alabama. 35812
   Reference: B65-10281

**Patent status**: NASA encourages the immediate commercial use of this invention. It is owned by NASA, and a patent application has been filed. When patented, royalty-free non-exclusive licenses for its commercial use will be available. Inquiries concerning license rights should be made to NASA, Code AGP, Washington, D.C., 20546.

Source: Avco Corporation under contract
to Marshall Space Flight Center
(M-FS-331)

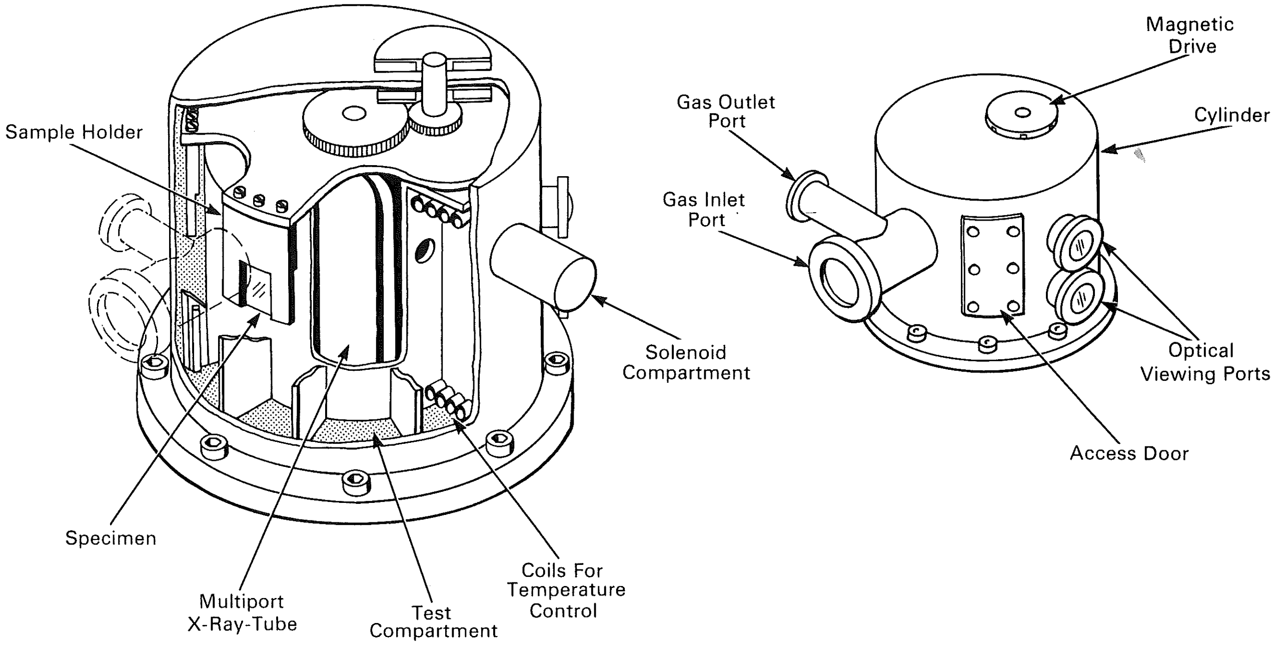
September 1965

Brief 65-10268

# NASA TECH BRIEF

NASA Tech Briefs are issued by the Technology Utilization Division to summarize specific technical innovations derived from the space program. Copies are available to the public from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia, 22151.

## Multiple Test Chamber Exposes Materials to Various Environments



**The problem:** To design a test chamber in which several material specimens can be conveniently subjected to X-rays and other environmental conditions for prolonged times (up to more than a year). Periodic measurements of the progressive changes occurring in the specimens must be made without requiring their removal from the chamber. Previously, after exposing a number of specimens in an environmental chamber it was necessary to remove them at various times in order to test them for the effects of the exposure. Such a program was unduly time consuming, since it required intermittent shutdown of the chamber and removal of the specimens, and also resulted in loss of environmental integrity of the specimens.

**The solution:** A test chamber providing a central source of X-rays, controlled gaseous atmospheres, and other means of exposing the material specimens to prescribed environmental conditions. The specimens are individually mounted in chamber compartments which can be rotated to various positions where measurements are made through optical windows and other test devices to determine the progressive changes in the material properties.

**How it's done:** The test chamber incorporates an outer rotatable cylindrical container and an inner stationary cylindrical member. The specimen compartments are formed by radial segmented walls. One segment of each wall is fixed to the outer cylindrical

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container and is separated by a small gap from a second wall segment fixed to the inner cylindrical member. A specimen holder is mounted in each compartment segment attached to the outer container. This container is secured to an outer top plate on which a gear mechanism is integrally mounted. At the top of the chamber housing is a driving member for the gear mechanism to allow each of the specimen holders to be rotated to different compartments. Two sets of permanent magnets connected to the drive system provide for rotation of the specimen holders without the need of sealed bearings to prevent chamber leakage.

Beryllium windows are provided in the inner cylindrical member to allow an X-ray source mounted within this member to irradiate the specimens in alternate compartments. Optical windows are provided around the circumference of the chamber to enable measurements of the specimens with a spectrometer. Inlet and outlet ports allow introduction of various gases into the chamber and withdrawal for analysis. The specimens in the compartments may be heated or cooled to desired temperatures by circulating fluid in coils extending through the stationary side walls in each compartment. A solenoid compartment attached to the chamber opposite one of the internal compartments is used to deflect the samples by known amounts for mechanical tests. Deflections may be read on a cathetometer mounted on an appropriately positioned optical window.

**Note:** Inquiries concerning this invention may be directed to:

Technology Utilization Officer
Manned Spacecraft Center
P.O. Box 1537
Houston, Texas, 77001
Reference: B65-10268

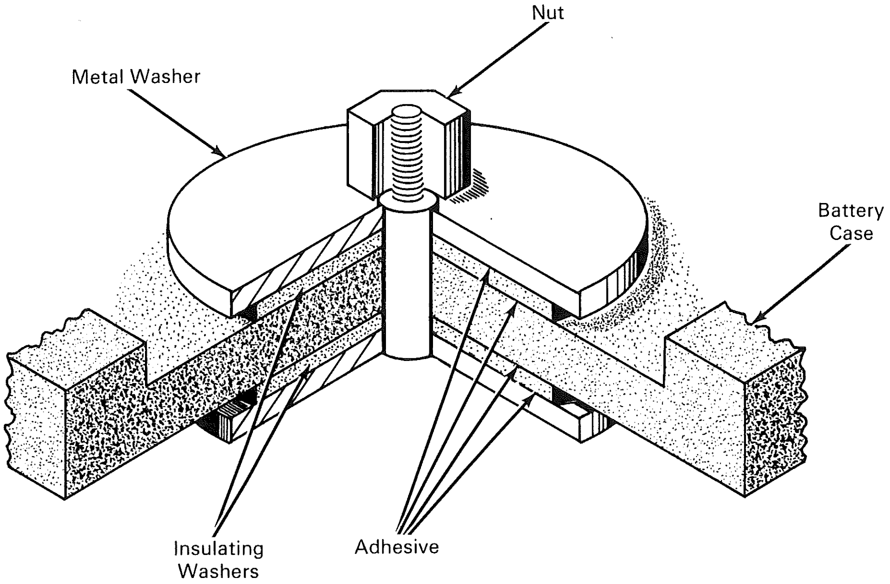
**Patent status:** NASA encourages the immediate commercial use of this invention. It is owned by NASA, and a patent application has been filed. When patented, royalty-free non-exclusive licenses for its commercial use will be available. Inquiries concerning license rights should be made to NASA, Code AGP, Washington, D.C., 20546.

Source: Robert L. Johnston
(MSC-179)

September 1965 Brief 65-10271

# NASA TECH BRIEF

## Composite Seal Reduces Alkaline Battery Leakage



**The problem:** To reduce leakage through alkaline battery seals. Present seals frequently develop leaks or fail under reduced pressure because the adhesive fails. A plastic sealant such as epoxy resin may be applied to critical areas of a seal, but even such a sealant cannot withstand the erosive action of caustic electrolyte for prolonged periods.

**The solution:** A composite seal consisting of rubber or plastic insulating washers and a metal washer, all held together mechanically. An adhesive is applied at each washer interface.

**How it's done:** The insulating washers may be made of materials such as polypropylene nonwoven fabric or neoprene rubber sheet. An adhesive is applied to each of the four interface surfaces between the metal and insulating materials. The adhesive should be the same material used to impregnate the polypropylene fabric if that is the insulator used. In the case of the neoprene rubber sheet as insulator, sheet epoxy, urethane, or neoprene adhesives should be applied. When the sheet adhesive is used with neoprene, the components are assembled dry and heated in an oven to cure the adhesive.

**Notes:**

1. Because this design provides positive sealing on both sides of the battery case, it is not affected by pressure differentials in either direction.
2. Seals using various combinations of insulating washers and adhesives were cyclically tested in

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caustic electrolyte at pressures up to 1,000 psig. Most seals retained their integrity for at least 52 weeks.

3. Because of simplicity of design, this seal can be produced by low-cost, production line methods.
4. Inquiries concerning this invention may be directed to:

   Technology Utilization Officer
   Goddard Space Flight Center
   Greenbelt, Maryland, 20771
   Reference: B65-10271

**Patent status:** NASA encourages the immediate commercial use of this invention. It was invented by NASA employees and a patent application has been filed. Inquiries concerning license rights may be made directly to the inventors, Mr. Karl F. Plitt and Mr. Carroll H. Clatterbuck at Goddard Space Flight Center, Greenbelt, Maryland, 20771.

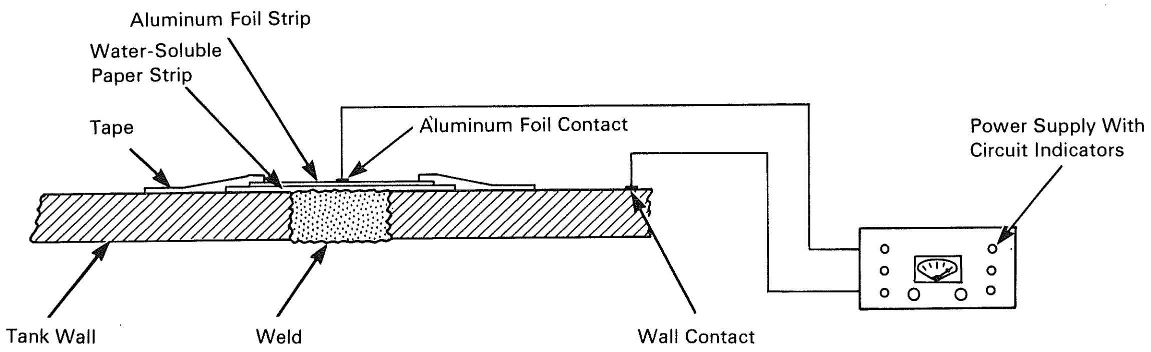
Source: (GSFC-337)

September 1965

Brief 65-10265

NASA TECH BRIEF

# Weld Leaks Rapidly and Safely Detected



**The problem:** To detect leaks that occur during hydrostatic pressure testing of welded joints in metal tanks.

**The solution:** A strip of aluminum foil electrically insulated from the tank by a strip of water-soluble paper is placed over the weld on the outside surface of the tank. A voltage applied between the tank wall and the foil strip is monitored to detect a decrease in ohmic resistance caused by water leakage into the paper layer.

**How it's done:** Adhesive tape placed along the edges of the aluminum foil and water-soluble paper holds them in proper position over the welded joint. An ohmmeter circuit (with an audible or a visual alarm system) indicates the large decrease in resistance that occurs when the hydrostatic pressure in the tank forces water through a leaky weld into the paper. Separate strip assemblies can be placed over each of the welded joints and connected to the monitoring circuit during one test. When an indication of a leak is recorded for a particular welded joint, the exact area where the leak has occurred can be determined after shutdown of the hydrostatic pressure and removal of the tape and aluminum strip. A clear area due to solution of the paper identifies the site of the leak.

**Notes:**

1. This test method has the following advantages:
   - a. Safety to personnel is assured since no one need be in the test area until the hydrostatic pressure is removed.
   - b. No paints or dyes that can contaminate the tank are used.
   - c. Black light or TV cameras are not required.
   - d. The tape, foil, and paper are commercially available materials which can be prepackaged into suitable rolls. The power supply and indicator circuits can easily be constructed from standard electrical components.

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2. Inquiries concerning this innovation may be directed to:

   Technology Utilization Officer
   Marshall Space Flight Center
   Huntsville, Alabama, 35812
   Reference: B65-10265

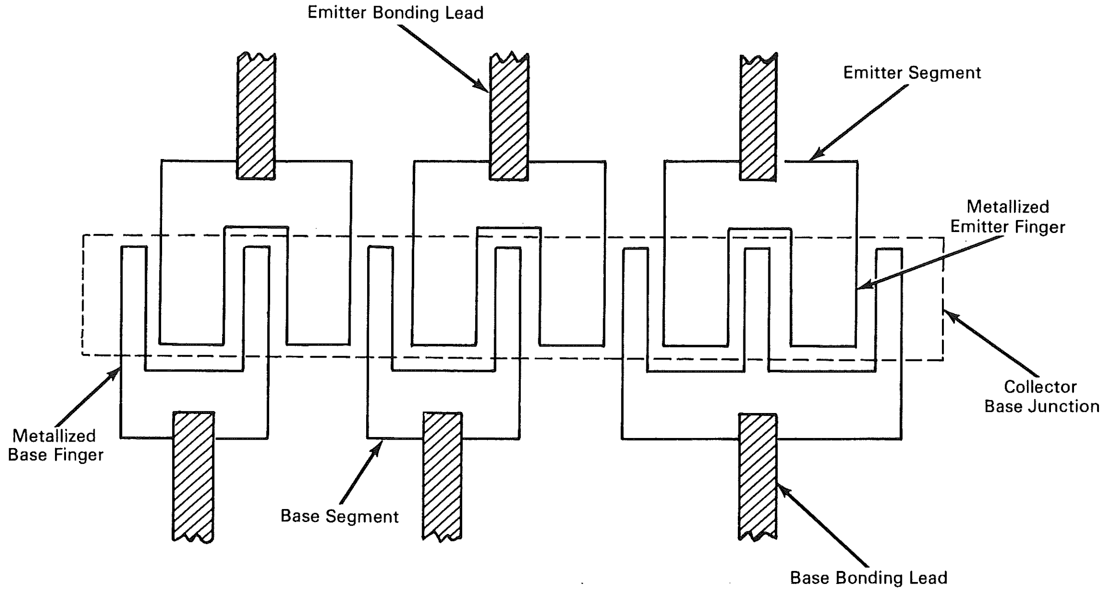
**Patent status:** NASA encourages commercial use of this innovation. No patent action is contemplated by NASA.

Source: The Boeing Company
under contract to
Marshall Space Flight Center
(M-FS-362)

September 1965 Brief 65-10259

# NASA TECH BRIEF

## Increased Junction Lead Inductance Ballasts High-Frequency Transistors



**The problem:** To evenly distribute the current across the junctions of a high-frequency transistor in order to prevent one section from drawing a destructive amount of current. Resistance balancing of each junction accomplishes this but seriously degrades the gain of the device.

**The solution:** The transistor bonding stripes are divided into segments and the inherent inductance of the individual leads is used to provide the necessary ballast to inhibit current runaway.

**How it's done:** The base and emitter bonding stripes are broken up into separate segments or pellets. If one section starts to draw more current, the voltage drop in both the emitter and base bonding leads of that segment, due to the inherent inductance of the bonding wires, will inhibit that segment from drawing further current. For example, the leads of a certain transistor are 40 mils long and 1 mil in diameter. The inductance is 1 nanohenry and the inductive reactance at 430 megacycles is 2.5 ohms. Each segment draws approximately 100 milliamps at high levels. If one segment starts to draw 25 milliamps more than another segment, a 62-millivolt additional voltage drop will occur in the emitter bonding lead alone. This is more than enough potential difference across the emitter-base junction to prevent any further current draw by the segment attempting to hog the current.

**Notes:**

1. One advantage of this technique is that use is being made of inductance inherently present in the device.
2. Because it lends itself to high-frequency (430 mc),

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high-power (20 watt) transistors, this invention should interest manufacturers of components for uhf equipment.

3. Inquiries concerning this invention may be directed to:

Technology Utilization Officer
Goddard Space Flight Center
Greenbelt, Maryland, 20771
Reference: B65-10259

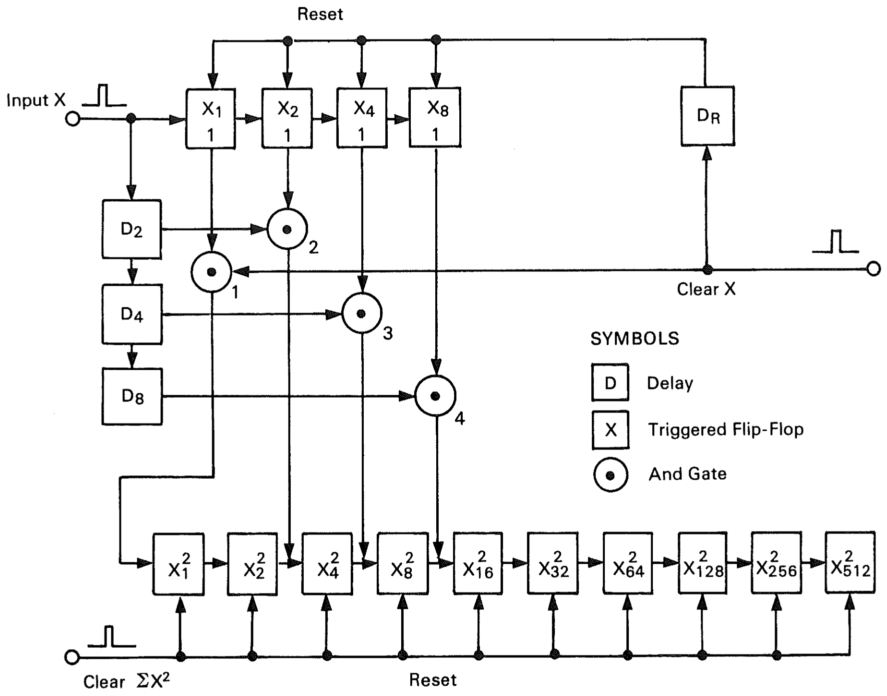
**Patent status:** NASA encourages the immediate commercial use of this invention. Inquiries about obtaining rights for its commercial use may be made to NASA, Code AGP, Washington, D.C., 20546.

Source: George J. Gilbert of
Radio Corporation of America
under contract to
Goddard Space Flight Center
(GSFC-387)

September 1965 Brief 65-10260

NASA TECH BRIEF

# Simple Pulse Counting Circuit Computes Sum of Squares



**The problem:** To calculate the sum ($\Sigma$) of the squares ($X^2$) of numbers represented by a series of pulse trains. Previous circuits designed to calculate $\Sigma X^2$ required the conversion of the pulse trains to binary representation and then the performance of standard computer squaring and adding processes. Where it is desired to display the results instantaneously, such as in a digital readout meter, standard computer techniques are not adequate.

**The solution:** A pulse counting circuit that includes an additional chain of flip-flops, delay lines plus and/gates to instantaneously compute the sum of the squares of the pulse sequences.

**How it's done:** The circuit configuration shown uses 4 flip-flops to count up to 15 and 10 additional flip-flops to store the sum of the squares. The four primary counting flip-flops are reset by a pulse on the clear X line after each sequence of pulses. At the end of the summation, the 10 summing flip-flops are cleared by a pulse on the clear $\Sigma X^2$ line.

In a typical operation, three sequential pulses arrive at the input X terminal and the first turns on flip-flop

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$X_1$. The second pulse turns $X_1$ off, $X_2$ on, and also travels through delay line $D_2$ to trigger flip-flop $X^2{}_4$. The third pulse, in a similar manner, causes $X^2{}_4$ to turn off and $X^2{}_8$ to turn on. Before the primary counter is reset, the $\Sigma X^2$ counter differs from the actual sum of the squares by one if the number of input pulses is odd. This is corrected when the clear X pulse arrives and triggers the $X^2$ flip-flop. For an even number of input pulses, the clear X pulse is not passed by and gate 1 because flip-flop $X_1$ is off.

## Notes:

1. Approximately $\log_2$ N gates and delay lines and 3 $\log_2$ N flip-flops would be required to compute the sum of the squares up to N pulses.
2. The advantage of this system is that, as a pulse train is completed, summation of the squares of the pulses is simultaneously completed.
3. This invention should be of interest to manufacturers of analog-to-digital converters and digital voltage and power meters.
4. Inquires concerning this invention may be directed to:

Technology Utilization Officer
Goddard Space Flight Center
Greenbelt, Maryland, 20771
Reference: B65-10260

**Patent status:** NASA encourages the immediate commercial use of this invention. It is owned by NASA and inquiries about obtaining royalty-free rights for its commercial use may be made to NASA, Code AGP, Washington, D.C., 20546.

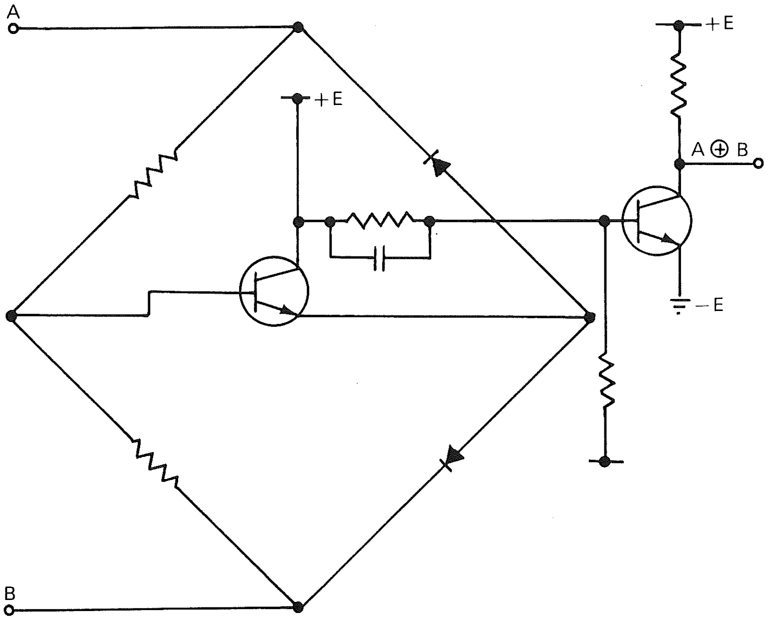
Source: David H. Schaefer
(GSFC-391)

September 1965

Brief 65-10275

# NASA TECH BRIEF

## Improved Circuit Minimizes Generation Time of Pseudonoise Check Bits



TWO-VARIABLE MOD-2 CIRCUIT

**The problem:** To design a computer switching network in which all the check bits in a pseudonoise (PN) sequence are generated in parallel with a minimum propagation time. A PN sequence contains $2^k$-1 bits derived from k information or generating bits and is used in certain computer algebraic coding procedures. Excessive computer time is required in earlier designs which use a recycling check bit shift register and an information bit comparator.

**The solution:** A switching network consisting primarily of parallel and series combinations of modulo 2 (mod 2) adders. This network uses the minimum number of gating levels (hence minimizing the propagation time) and optimally balances the loads on the individual mod 2 circuits.

**How it's done:** The pseudonoise sequence is described by the recursion formula:

$$X_n = \sum_{i=1}^{k} C_i X_{n-i}$$

where $C_i$ is either 0 or 1, $X_n$ is an information bit, k is the number of information bits, and the sum is obtained by mod 2 addition. For binary digits, this addition is done with *exclusive-or* ⊕ logic circuits of the type illustrated. Although in principle any number

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(k) of information bits can be processed by an appropriate parallel and series combination of these circuits, the description will be confined to the case of 6 information bits ($X_0, X_1, \ldots, X_5$) for simplicity. In this case, the PN sequence terms or check bits to be generated are ($X_6, X_7, \ldots, X_{62}$) and the recursion relation between the elements of this sequence is:

$$X_n = X_{n-6} \oplus X_{n-5}$$

Using this relation, each of the check bits can be reduced to a mod 2 function of from 2 to 6 of the information bits. Since mod 2 summing is an associative operation, the outputs of the mod 2 functions for two variables can be economically used as inputs to mod 2 functions of higher order. To derive the mod 2 function for 2, 3, 4, 5, and 6 variables, a two-term mod 2 circuit may be cascaded in one of several ways. The deciding factors are minimum propagation time and optimal load balance on the individual mod 2 circuits.

**Note:**

Inquiries concerning this invention may be directed to:

Technology Utilization Officer
Jet Propulsion Laboratory
4800 Oak Grove Drive
Pasadena, California, 91103
Reference: B65-10275

**Patent status:** NASA encourages the immediate commercial use of this invention. It is owned by NASA and inquiries about obtaining royalty-free rights for its commercial use may be made to NASA, Code AGP, Washington, D.C., 20546.

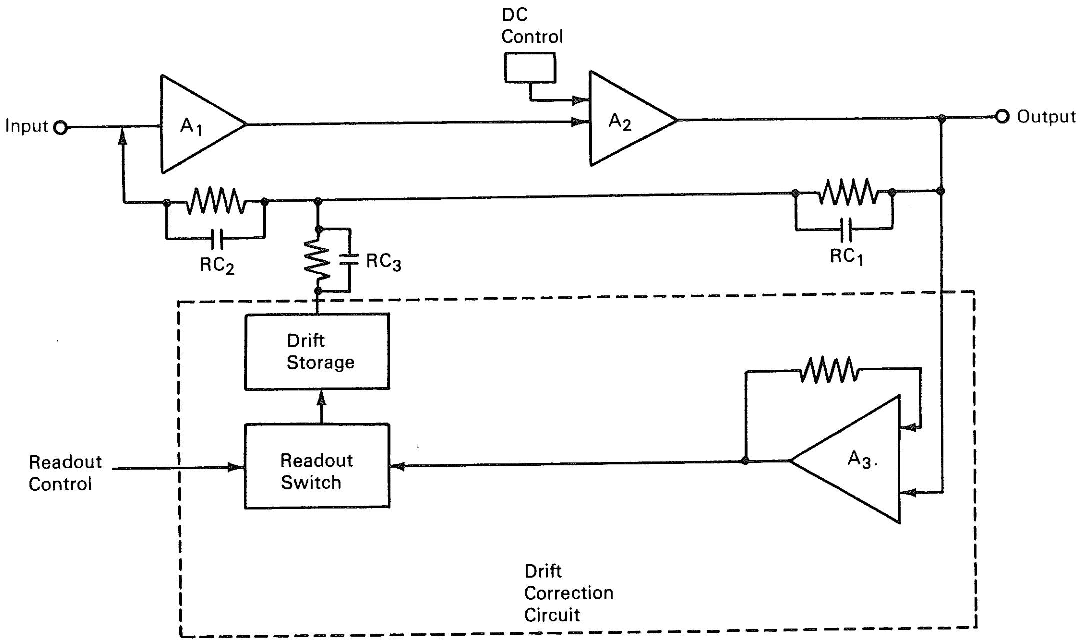
Source: T. O. Anderson and W. A. Lusbaugh
(JPL-698)

September 1965

Brief 65-10267

# NASA TECH BRIEF

## Electrometer Preamplifier Has Drift Correction Feedback



**The problem:** Correcting for output drift in an electrometer. Because the electrometer is operated in a keyed (noncontinuous) mode, when no output signal is being applied, output level must be maintained at zero or some constant reference level in order that readout be accurate when an input signal is next applied.

**The solution:** A circuit using negative feedback in the no signal state to maintain the output level at zero reference and using drift voltage storage in the signal on state to provide drift-free readout.

**How it's done:** A conventional electrometer preamplifier consists of amplifiers $A_1$ and $A_2$, and the negative feedback network consisting of $RC_1$, $RC_2$, and $RC_3$. The output level is set to the zero reference level by adjusting the dc control on $A_2$ just prior to readout. When the drift correction circuit is added, any drift from the zero reference level produces a large change in the voltage level at the output of $A_3$, a differential input transistor amplifier with high dc stability. The output from $A_3$ is fed through the readout switch to the drift storage circuit and then to the feedback network as negative feedback, thereby maintaining the preamplifier output at the zero reference level. When a signal is applied to the preamplifier, a signal is also applied to the readout switch which disconnects the drift correction circuit from the

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preamplifier. The drift storage circuit maintains the drift correction voltage that existed prior to readout for 10 to 20 seconds, thus ensuring that the voltage at the preamplifier output is always relative to the required zero reference voltage level.

**Notes:**

1. This invention should have application in any circuit which requires high input impedance and operates in a keyed mode.
2. Inquiries concerning this invention may be directed to:

Technology Utilization Officer
Jet Propulsion Laboratory
4800 Oak Grove Drive
Pasadena, California, 91103
Reference: B65-10267

**Patent status:** NASA encourages the immediate commercial use of this invention. Inquires about obtaining rights for its commercial use may be made to NASA, Code AGP, Washington, D.C., 20546.

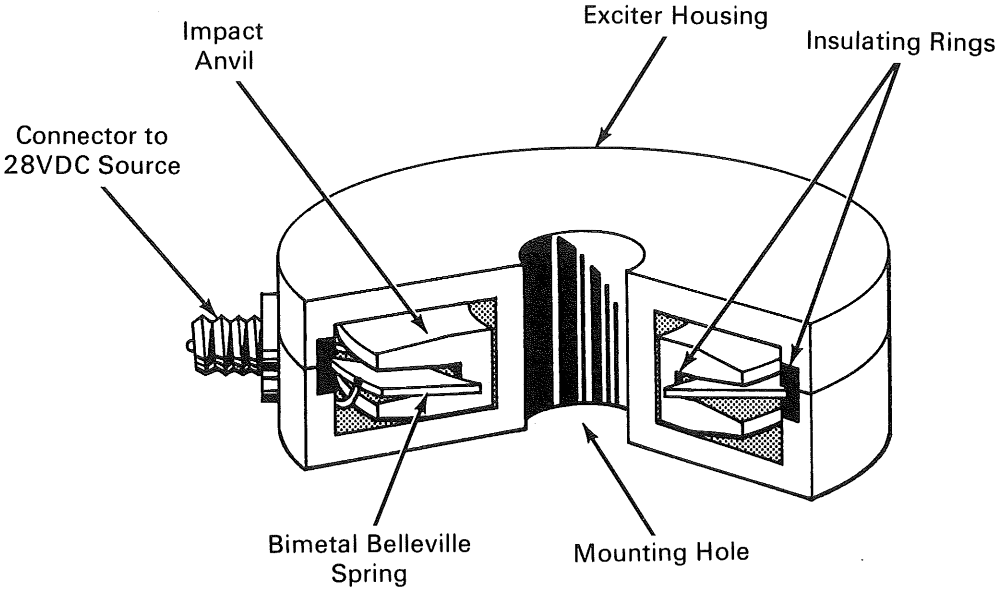
Source: L. C. Labarthe of
Labko Scientific, Inc.
under contract to
Jet Propulsion Laboratory
(JPL-SC-074)

September 1965
Brief 65-10269

# NASA TECH BRIEF

NASA Tech Briefs are issued by the Technology Utilization Division to summarize specific technical innovations derived from the space program. Copies are available to the public from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia, 22151.

## Simple Device Produces Accelerometer Calibration Pulse



**The problem:** To provide a simple device for remote checkout of the amplitude calibration and frequency response of a piezoelectric vibration accelerometer. Devices which use an ac-excited second piezoelectric crystal in the accelerometer housing are not dependable because of difficulties in controlling the ac signal amplitude.

**The solution:** A shock-impulse exciter employing a bimetal spring to apply a mechanical acceleration pulse of a known amplitude and frequency to the accelerometer.

**How it's done:** The exciter (0.75-in. i.d. × 0.25-in. thick) is mounted as a washer between the accelerometer and the surface of the equipment to be tested. The exciter anvil is normally held firmly against one surface of the exciter housing by the bimetal Belleville spring. The spring is electrically insulated from the housing and the anvil by the insulation rings. When a dc voltage from a remote source is applied to the bimetal spring, a current flow through the spring causes it to heat and deflect slowly until it snaps into a negative deflection, pulling the anvil away from the housing. At this point the voltage is interrupted and the spring begins to slowly deflect toward its original position. This deflection continues until the spring snaps back into its original position, impacting the anvil against the housing. The shock impact is transmitted through the housing to the accelerometer, which provides an electrical output pulse to a readout.

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The acceleration amplitude due to the exciter shock is determined by a laboratory calibration of the accelerometer-exciter combination. The frequency response can be checked by observing the accelerometer's output rise time or ringing frequency.

**Note:**

Inquiries concerning this innovation may be directed to:

Technology Utilization Officer
Marshall Space Flight Center
Huntsville, Alabama, 35812
Reference: B65-10269

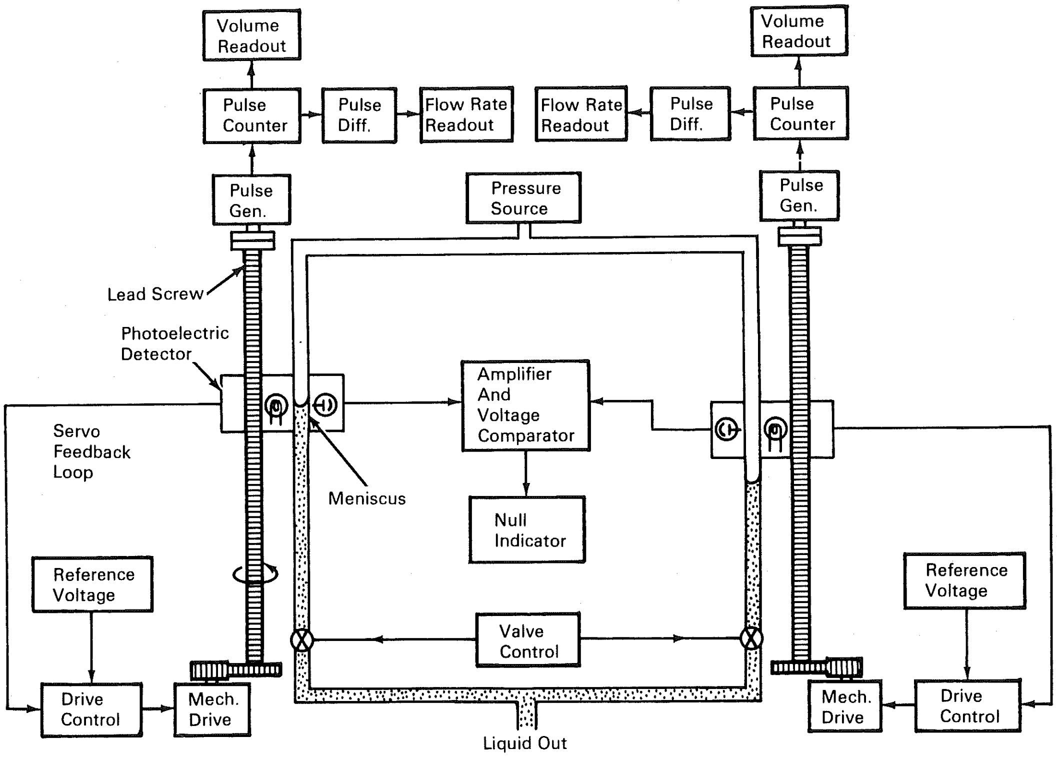
**Patent status:** NASA encourages commercial use of this innovation. No patent action is contemplated by NASA.

Source: Lockheed Missiles and Space Company
under contract to
Marshall Space Flight Center
(M-FS-363)

September 1965 Brief 65-10273

# NASA TECH BRIEF

## Electromechanical Flowmeter Accurately Monitors Fluid Flow


Volume Readout
Pulse Counter
Pulse Diff.
Flow Rate Readout
Flow Rate Readout
Pulse Diff.
Pulse Counter
Volume Readout
Pulse Gen.
Pressure Source
Pulse Gen.
Lead Screw
Photoelectric Detector
Amplifier And Voltage Comparator
Servo Feedback Loop
Meniscus
Null Indicator
Reference Voltage
Reference Voltage
Valve Control
Drive Control
Mech. Drive
Mech. Drive
Drive Control
Liquid Out

**The problem:** Providing an instrument that will remotely and accurately monitor the flow rate and total volume of a transparent liquid being discharged from a dispensing system. One approach for continuous flow indication is through the use of a photoelectric detector and light source that are mechanically driven along a transparent dispensing tube to track or follow the displacement of the liquid meniscus. Previous instruments based on this approach do not give an accurate indication of the total amount of liquid dispensed since they depend upon an inherently inaccurate reference point that cannot be set from a remote location. These instruments do not compensate for temperature variations which expand or contract the liquid and thus alter the level of the meniscus in the dispensing tube.

**The solution:** An electromechanical flowmeter employing two similar dispensing tubes and two photoelectric detectors that are accurately driven on lead screws to track the meniscus in each tube. A null indicator connected to the outputs of the detectors

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fixes the level of the liquid in one tube as a reference with respect to the level of the liquid in the other tube. Compensation for any temperature variations is maintained by alternately referencing between the two tubes as the liquids are dispensed.

**How it's done:** A gas pressure source and two remotely controlled valves connected to each of the dispensing tubes are used to regulate the flow of liquid from the system. The photoelectric detectors are positioned for parallel longitudinal movement along the dispensing tubes to sense the position of each meniscus. Signals from the detectors are coupled to a conventional amplifier and voltage comparator circuit which in turn is connected to a null indicator. This indicator registers a null or minimum reading only when the voltage levels of the signals from the two detectors are approximately equal and thus establishes the position of the meniscus in one of the tubes as a reference for the meniscus in the second tube.

As liquid is dispensed, each detector independently tracks the displacement of the meniscus in the tube with which it is associated. The detector outputs and reference voltages (equal to the output voltages from the respective detectors) are fed to the remote drive controls which regulate the variable-speed motors that drive the detectors along the lead screws. For each of the dispensing tubes, the electrical output line from the detector, the drive control, the mechanical drive, and the lead screw constitute a feedback circuit which automatically positions the detector in accordance with the position of the meniscus of the liquid in the corresponding tube. The pulse generators, coupled to each lead screw, generate a predetermined number of pulses for each revolution of the lead screw. The pulse counters and readouts, by means of multiplication circuitry not shown, give the volume of liquid dispensed. Liquid flow rates are obtained by connecting the pulse counters to pulse differentiators and additional readouts.

**Notes:**

1. Since the entire operation may be controlled from a remote station, this flowmeter should be particularly useful for accurately monitoring the flow of small quantities of hazardous (radioactive toxic, or explosive) liquids, or liquids that must be dispensed in closed chambers, such as vacuum chambers.

2. The same principle of operation may be used with more than two dispensing tubes.

3. Instead of using the dual dispensing tube system to provide a relative level reference between the liquids in each tube, the same principle can be applied to one or more tubes by connecting an independent reference voltage source to the amplifier and voltage comparator.

4. If the dispensing tube or liquid is opaque, magnetic detectors may be used instead of the photoelectric detectors. In this case, a buoyant slug containing magnetic material will have to be placed on the liquid surface in the tube.

5. Inquiries concerning this innovation may be directed to:

   Technology Utilization Officer
   Goddard Space Flight Center
   Greenbelt, Maryland, 20771
   Reference: B65-10273

**Patent status:** NASA encourages the immediate commercial use of this invention. It is owned by NASA, and a patent application has been filed. When patented, royalty-free nonexclusive licenses for its commercial use will be available. Inquiries concerning license rights should be made to NASA, Code AGP, Washington, D.C., 20546.

Source: Daniel J. Grant
(GSFC-357)

September 1965 Brief 65-10276

# NASA TECH BRIEF

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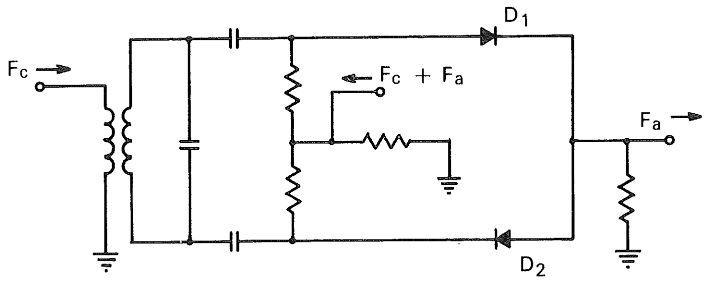
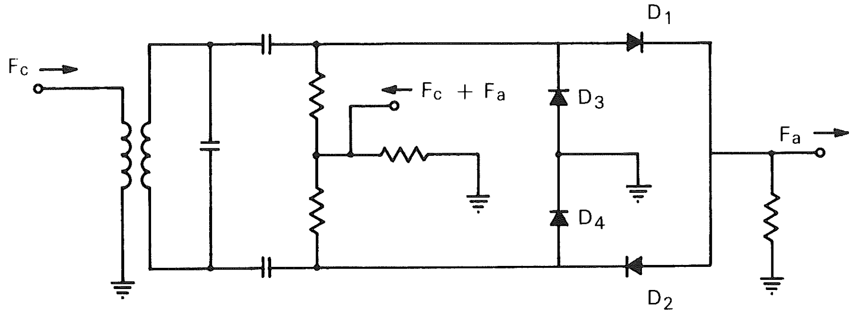
## Added Diodes Increase Output of Balanced Mixer Circuit



OLD CIRCUIT



IMPROVED CIRCUIT

**The problem:** To increase the output signal level of conventional balanced mixer circuits, commonly used in radio transmitting and receiving equipment, with a minimum of added components. It is desirable to avoid the addition of push-pull amplifiers as a means of summing out-of-phase outputs.

**The solution:** The addition of two diodes to form a half-wave carrier switch balanced modulator. This doubles the output signal level and reduces spurious output and distortion by one half.

**How it's done:** Two additional diodes, $D_3$ and $D_4$ with center tapped ground are added to a conventional balanced mixer. The result is a half-wave carrier switch balanced modulator that functions to generate a difference frequency $F_a$ (audio) at the output. The inputs $F_c$ and $F_c + F_a$ represent inputs at the carrier frequency and at the carrier plus audio frequencies, respectively. Addition of the centertap grounded diodes permits both legs of the circuit to function throughout the ac cycle. This effectively doubles the output frequency $F_a$ while the level of spurious signals at frequencies $F_c + F_a$ and $F_c - F_a$ is reduced by one half. Distortions caused by signals at the third harmonic of $F_a$ are also reduced by one half.

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**Notes:**

1. This invention should be of general interest to persons engaged in designing radio receivers and transmitters.
2. Inquiries concerning this invention may be directed to:

   Technology Utilization Officer
   Goddard Space Flight Center
   Greenbelt, Maryland, 20771
   Reference: B65-10276

**Patent status:** NASA encourages the immediate commercial use of this invention. Inquiries about obtaining rights for its commercial use may be made to NASA, Code AGP, Washington, D.C., 20546.

Source: George B. Robinson
(GSFC-354)

September 1965 Brief 65-10278

# NASA TECH BRIEF

## Modified Developer Increases Line Resolution in Photosensitive Resist

**The problem:** To increase the line resolution and reduce the number of pinholes in films formed from a standard commercially available metal etch resist used in thin-film technology and in the fabrication of printed circuitry and semiconductors. Lines narrower than 0.001 inch cannot be produced in the resist because it swells when processed with standard developers. When the thickness of the resist film is reduced to minimize the swelling caused by these developers, pinholes appear in the film.

**The solution:** An additive is mixed with the developer to reduce the swelling action in the resist and to permit application of relatively thick films in which the formation of pinholes is minimized.

**How it's done:** The standard developer solution is mixed with 50% by weight of dipropyl carbonate. Lines less than 0.0001 inch wide can be easily produced in the resist using the modified developer and standard etching agents. The usual rinses following the development can be replaced by the dipropyl carbonate to improve the adhesion of the resist to the substrate.

**Note:**

1. Inquiries concerning this invention may be directed to:

Technology Utilization Officer
Goddard Space Flight Center
Greenbelt, Maryland, 20771
Reference: B65-10278

**Patent status:** NASA encourages the immediate commercial use of this invention. It is owned by NASA and inquiries about obtaining royalty-free rights for its commercial use may be made to NASA, Code AGP, Washington, D.C., 20546.

Source: Westinghouse Electric Corporation
under contract to
Goddard Space Flight Center
(GSFC-386)

Categories 01, 03

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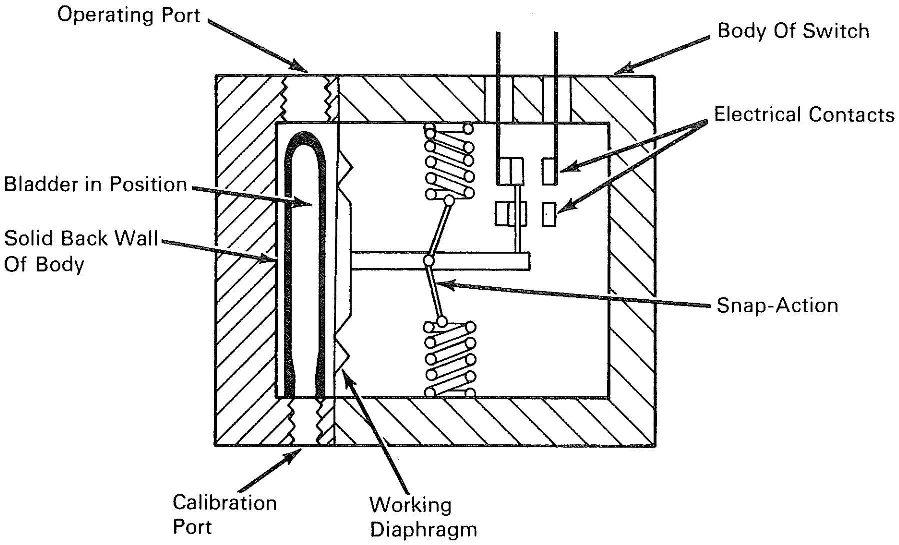
September 1965 Brief 65-10279

# NASA TECH BRIEF

## Inflatable Bladder Provides Accurate Calibration of Pressure Switch



**The problem:** To accurately check the calibration of a pressure switch with minimum disturbance to normal operation of the switch. The use of a second, or calibration diaphragm can introduce errors related to differences in spring rates. It may also permit the calibration fluid to interact with the operational fluid.

**The solution:** A thin-walled, circular bladder is placed inside the pressure switch and connected to an independent external pressure source that causes the bladder to expand and apply a force to the switch diaphragm.

**How it's done:** In calibrating the pressure switch, pressure at the operating port is first removed. Calibration pressure is then applied to the calibration port, inflating the bladder and applying an equally distributed force to the surface of the switch diaphragm. Because the calibration bladder exhibits practically zero spring rate, negligible work is done in the inflating process and pressure applied to the switch diaphragm by the bladder is essentially the same as normal working pressure. When working pressure is reapplied to the operating diaphragm and calibration pressure is removed, the bladder collapses and seals off the calibration port.

**Notes:**

1. The bladder, if formed of a suitable inert elastic material, would be useful with a wide variety of fluids.
2. This technique may be used with any conventional pressure switch where periodic calibration checks are desirable during normal usage.

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3. Inquiries concerning this invention may be directed to:

   Technology Utilization Officer
   Marshall Space Flight Center
   Huntsville, Alabama, 35812
   Reference: B65-10279

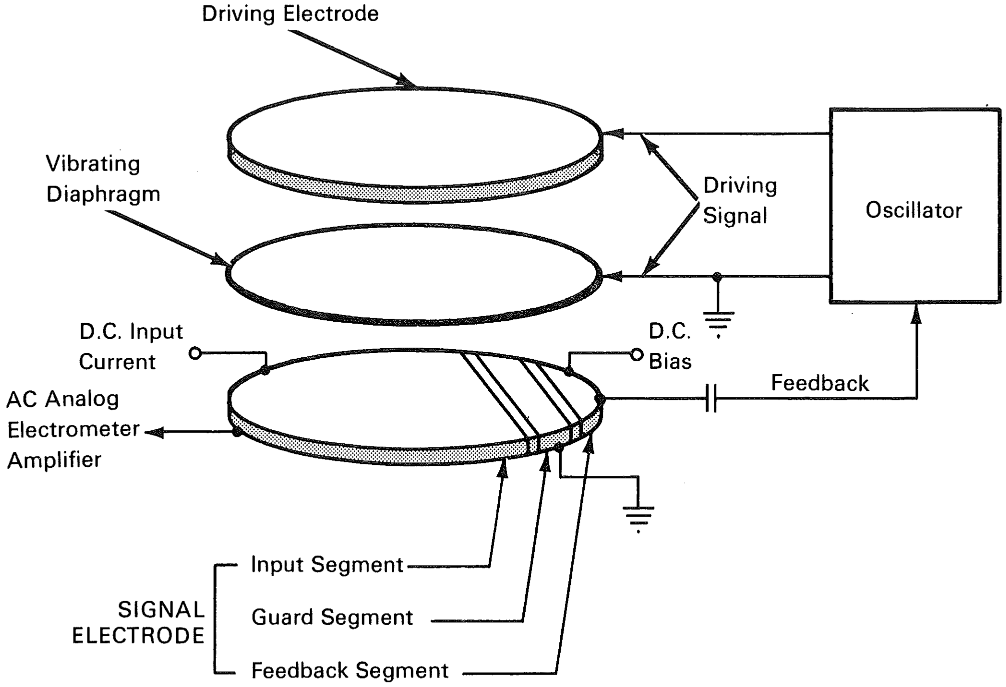
**Patent status:** NASA encourages the immediate commercial use of this invention. Inquiries about obtaining rights for its commercial use may be made to NASA, Code AGP, Washington, D.C., 20546.

Source: Norman J. Smith of
The Boeing Company
under contract to
Marshall Space Flight Center
(M-FS-367)

October 1965 Brief 65-10293

# NASA TECH BRIEF

## Electrostatically Driven Dynamic Capacitor Employs Capacitive Feedback


Driving Electrode
Vibrating Diaphragm
Driving Signal
Oscillator
D.C. Input Current
D.C. Bias
Feedback
AC Analog Electrometer Amplifier
SIGNAL ELECTRODE
Input Segment
Guard Segment
Feedback Segment

**The problem:** To provide regenerative feedback to an oscillator driving a dynamic capacitor in the input stage of an electrometer circuit. Prior art used a variable reluctance pickup having a single input electrode on the side of the vibrating diaphragm opposite the driving electrode. Difficulty has been experienced in providing sufficient feedback from the variable reluctance pickup and in sufficiently reducing its temperature coefficient.

**The solution:** A circuit that substitutes a three-part signal electrode for the single variable reluctance pickup electrode to supply capacitive feedback to the driving oscillator.

**How it's done:** The dynamic capacitor consists of three basic elements: a driving electrode, a vibrating diaphragm, and a three-segment signal electrode. Alternating current voltage from the oscillator makes the diaphragm vibrate at its resonant frequency, causing the capacitance between the segmented signal electrode and grounded diaphragm to vary at the same frequency. An ac analog of the dc input is developed between the input segment and ground to drive the associated electrometer amplifier. In the same manner, the fixed dc bias voltage applied to the feedback segment of the signal electrode develops an ac feedback signal in response to diaphragm motion. Because

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the bias voltage can be made as large as desired, sufficient feedback signal can be obtained in spite of the poor conversion efficiency of the feedback segment. The guard segment of the signal electrode prevents leakage of the bias voltage to the high-impedance input segment and the grounded diaphragm prevents coupling between the driving and signal electrodes.

**Notes:**

1. This innovation should be of interest to manufacturers of electrometers.
2. Inquiries concerning this innovation may be directed to:

Technology Utilization Officer
Jet Propulsion Laboratory
4800 Oak Grove Drive
Pasadena, California, 91103
Reference: B65-10293

**Patent status:** NASA encourages commercial use of this innovation. No patent action is contemplated by NASA.

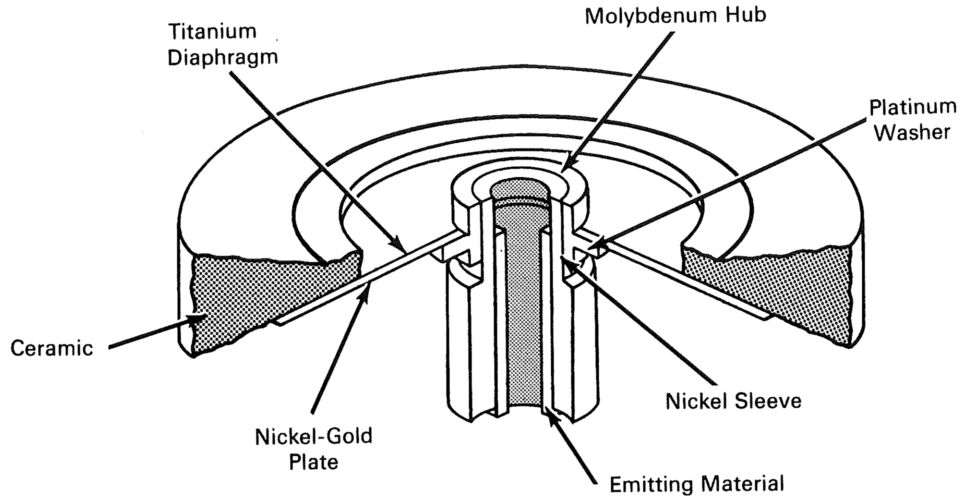
Source: James O. Lonborg
(JPL-771)

October 1965

Brief 65-10298

# NASA TECH BRIEF

## Titanium Diaphragm Makes Excellent Amplitron Cathode Support



**The problem:** To prevent radial misalignment between the cathode and anode in amplitrons.

**The solution:** A cathode support structure designed around a titanium diaphragm that exhibits low thermal conductivity, tolerates lateral thermal expansion of the cathode, and is a poor primary and secondary emission medium.

**How it's done:** The titanium diaphragm is brazed to the ceramic support structure after first metallizing the surface of the ceramic by conventional techniques. A gold-nickel eutectic is used as a brazing material since it melts in a desirable temperature range. A molybdenum hub isolates the nickel cathode from the titanium diaphragm since their eutectic point is at approximately the same temperature as that required during cathode processing. The molybdenum hub is welded to the titanium diaphragm with a thin platinum washer. The cathode is welded to the molybdenum hub after the parts have been assembled in the amplitron tube.

**Notes:**

1. The strength of titanium, even at elevated temperatures, allows lateral thermal expansion of the cathode without loss of the necessary radial alignment with respect to the anode.
2. Because of its poor primary and secondary emission characteristics, the titanium acts as an end shield to prevent spreading of the electron cloud in the interaction space. It also contributes to performance stability by its effective absorption of residual gases in a high-vacuum environment.

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3. Inquiries concerning this innovation may be directed to:

   Technology Utilization Officer
   Goddard Space Flight Center
   Greenbelt, Maryland, 20771
   Reference: B65-10298

**Patent status:** NASA encourages commercial use of this innovation. No patent action is contemplated by NASA.

Source: W. W. Teich of Raytheon Company
under contract to
Goddard Space Flight Center
(GSFC-394)

October 1965 Brief 65-10299

# NASA TECH BRIEF

## Electropneumatic Rheostat Regulates High Current

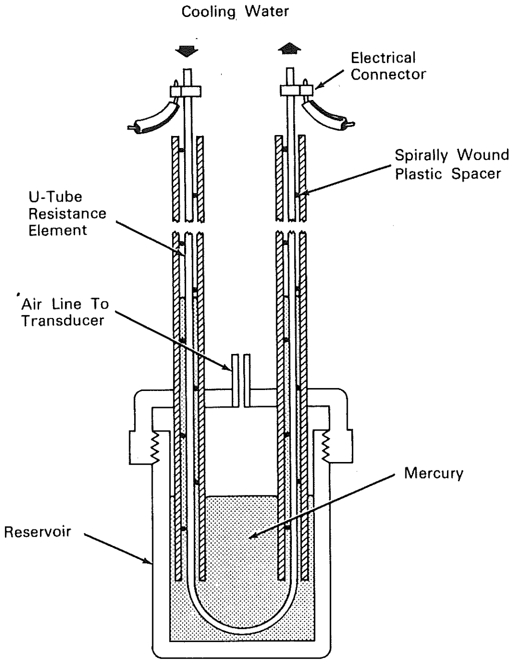
Cooling Water
Electrical Connector
Spirally Wound Plastic Spacer
U-Tube Resistance Element
Air Line To Transducer
Mercury
Reservoir

FIG. 1

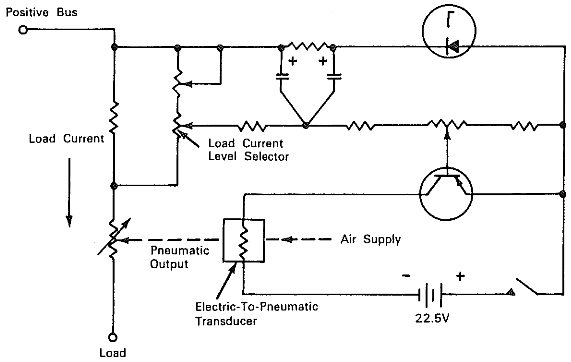
Positive Bus
Load Current
Load Current Level Selector
Pneumatic Output
Air Supply
Electric-To-Pneumatic Transducer
- +
22.5V
Load

FIG. 2

**The problem:** To maintain a constant direct current in each of several high-power (megawatt range) parallel loads, of characteristically variable resistance, across a single source. It was desirable to use a single available dc generator to avoid purchasing separate power supplies, rectifiers, or rotary machines.

**The solution:** A simple, automatically-controlled rheostat system that will provide current regulation at any preset value by dissipating the proper amount of energy thermally. The electropneumatic rheostat uses a column of mercury to vary the effective length of a resistance element.

**How it's done:** The resistance element of the rheostat is a U-shaped stainless steel tube, internally cooled, immersed in a mercury reservoir, each leg being centered within a standpipe of low electrical resistance by a spiral insulating spacer. Air pressure from an electric/pneumatic transducer forces the mercury in the reservoir to rise into the area between the standpipes and the resistance element. Because the resistance element is short circuited to the standpipes at the surface level of the mercury, the current bypasses that portion of the element below the surface level and flows through the low-resistance standpipes. The resistance of the rheostat is, therefore, inversely

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proportional to the applied air pressure. The control circuit senses changes in the load current and activates a commercially available electric/pneumatic transducer to convert a 0 to 5 milliamp dc signal to a 15 to 0 psi (inverse acting) pneumatic output that allows linear control of the rheostat. The load current level selector, a small potentiometer in the control circuit, serves as voltage divider in parallel with the load current shunt and permits manual changes in the control value of the load current. A plastic tube between the rheostat and transducer pneumatic output provides electrical isolation of the rheostat from the control circuit.

**Notes:**

1. This control system has been used to maintain constant current in each of five parallel dc circuits containing five electric arc loads, all supplied from a single dc source. A different current level could be set in each of the circuits. Because the loads are dc-arc discharges, which characteristically exhibit fluctuations in the load current, the control circuit is provided with ac filters that render the system insensitive to load fluctuations down to 10 cps with amplitude equal to the dc amplitude.
2. For this particular application, the rheostat units have a maximum resistance of about 0.8 ohm and are rated at 200 amperes for 1,000 psi cooling water.
3. Inquiries concerning this innovation may be directed to:

Technology Utilization Officer
Ames Research Center
Moffett Field, California, 94035
Reference: B65-10299

**Patent status:** NASA encourages commercial use of this innovation. No patent action is contemplated by NASA.

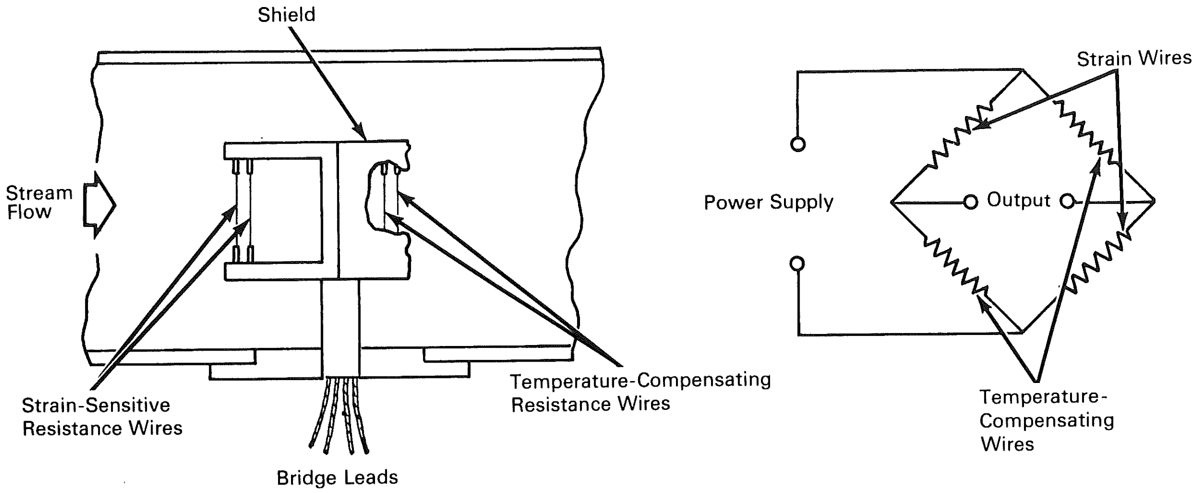
Source: Cleo B. Wagoner, Jack F. Häacker,
and James R. Jedlicka
(ARC-44)

October 1965

Brief 65-10304

# NASA TECH BRIEF

## Improved Strain-Wire Flowmeter Has Fast Response Time


Shield
Stream Flow
Strain-Sensitive Resistance Wires
Bridge Leads
Temperature-Compensating Resistance Wires
Strain Wires
Power Supply
Output
Temperature-Compensating Wires

**The problem:** To design a flowmeter that would give an electrical output as a measure of rapidly varying as well as steady fluid-flow rates.

**The solution:** The sensing element of the flowmeter consists of strain-sensitive resistance wires arranged in the form of a conventional Wheatstone bridge. The change in resistance of the wires is measured as a function of stream velocity.

**How it's done:** The strain-sensitive wires are suspended in the flow stream normal to the direction of flow. Two wires forming one pair of opposite bridge legs are directly exposed to the fluid flow. The viscous drag of the fluid, which is a function of stream velocity, strains these wires and therefore correspondingly changes their electrical resistance, in accordance with the strain-gage principle. The other two wires in the bridge are used to compensate for temperature variations of the fluid and are therefore shielded from the stream drag. The unbalance of the bridge due to stream velocity is measured using a conventional power supply and sensitive galvanometer system (not illustrated).

**Notes:**

1. All of the wires should be identical and suspended in the same manner.
2. In case temperature compensation is not required, only two wires would be suspended in the fluid and two external fixed resistors would be used to complete the bridge circuit.
3. The fine-wire sensing elements may be protected by screening against damage from material suspended in the fluid.

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4. Inquiries concerning this invention may be directed to:

   Technology Utilization Officer
   Lewis Research Center
   21000 Brookpark Road
   Cleveland, Ohio, 44135
   Reference: B65-10304

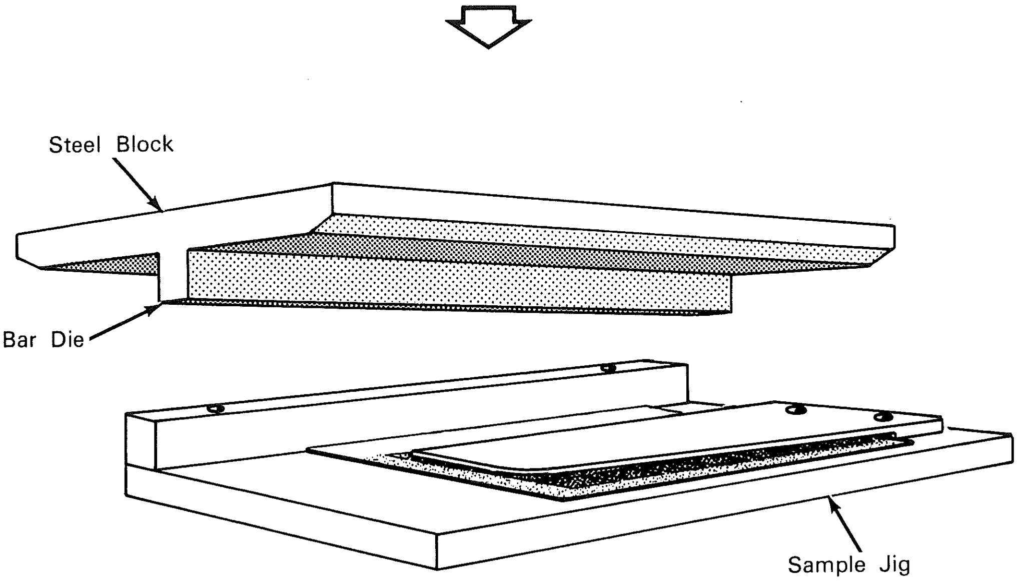
**Patent status:** NASA encourages the commercial use of this invention. It was invented by NASA employees, and U.S. Patent No. 3,114,261 has been issued to them. Inquiries about obtaining license rights for its commercial development should be addressed to the inventors, Mr. Richard C. Dillon and Mr. William R. Dunbar at Lewis Research Center.

Source: (Lewis-241)

October 1965 Brief 65-10306

# NASA TECH BRIEF

## Opaque Microfiche Masthead Permits Easy Reading



**The problem:** Microfiche, a form of microfilm, consists of a series of images of reduced size placed on a file-card size support for ease of storage and retrieval. The title and indexing information are photographed in full size type at the top of the microfiche to form the masthead. In order to read the titles and other masthead information, it is necessary to remove the microfiche from the file and hold it to back-lighting.

**The solution:** A white-pigmented backing applied to the reverse side of the masthead area to make it opaque so that the letters and numerals may be easily read.

**How it's done:** A roll leaf heat stamping press is used to apply a white-pigmented stamping foil in tape form to the reverse side of the masthead area. The press has a chase that accepts a steel block containing a bar die that is the size of the masthead area. A sample jig is placed on the base plate of the press to hold the microfiche in position. The stamping foil is manually positioned on the reverse of the masthead area and a combination of heat and pressure bonds it to the microfiche in much the same manner as lettering is bonded to luggage and other leather goods.

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**Notes:**

1. This invention should be of interest to organizations that are involved with large volume information storage and retrieval.
2. Inquiries concerning this invention may be directed to:

   Technology Utilization Officer
   National Aeronautics and Space Administration
   Code ATU
   Washington, D.C., 20546
   Reference: B65-10306

**Patent status:** NASA encourages the immediate commercial use of this invention. Inquiries about obtaining rights for its commercial use may be made to NASA, Code AGP, Washington, D.C., 20546.

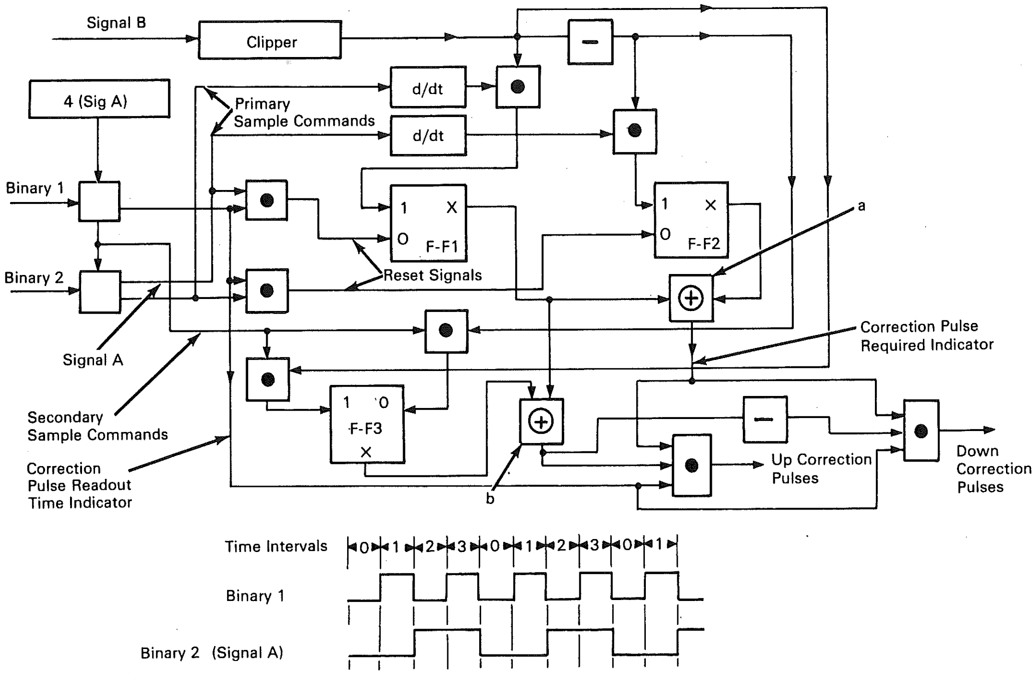
Source: Eugene M. Lowe of
Documentation Incorporated
under contract to NASA
(HQ-7)

October 1965

Brief 65-10307

NASA TECH BRIEF

# Frequency Correction Device Uses Digital Circuitry


Signal B
Clipper
4 (Sig A)
Primary
Sample Commands
d/dt
d/dt
Binary 1
Binary 2
1 X
O F-F1
Reset Signals
1 X
O F-F2
a
Signal A
Secondary
Sample Commands
Correction
Pulse Readout
Time Indicator
1 0
F-F3
X
b
Correction Pulse
Required Indicator
Up Correction
Pulses
Down
Correction
Pulses
Time Intervals
0 1 2 3 0 1 2 3 0 1
Binary 1
Binary 2 (Signal A)

**The problem:** To design a circuit that generates correction signals to control the frequency of a voltage-controlled oscillator in a system used to acquire and track incoming signals over a wide range of frequencies.

**The solution:** A digital circuit that samples the frequency of the incoming signal at prescribed time intervals and provides correction pulses to the voltage-controlled oscillator.

**How it's done:** The voltage-controlled oscillator signal, A, controls a sampling circuit that samples the incoming signal, B, once every half cycle of signal A (primary samples). If the frequencies of the two signals are exactly the same, no correction pulses are produced. If they are not the same, secondary samples taken at intermediate time intervals determine whether correction pulses should be generated to make signal A oscillate at the same frequency as signal B. As indicated in the block diagram, the basic oscillator puts out pulses at a frequency four times that of signal A itself to facilitate the application of necessary logic. This "times four" signal is counted down by the two counter stages (binary 1 and binary 2). The state of these binaries as a function of time interval is graphed below the block diagram. Primary samples are taken

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and remembered by the flip-flops during time intervals 0 and 2. During time intervals 1 and 3 one of the two flip-flops is being reset. If the frequencies of signals A and B are the same, both flip-flops (F-F) 1 and 2 will either be positive or negative during time intervals 0 and 2, and there will be no output from the *exclusive or* circuit *a*. In the absence of an output from this circuit, there will be no "up" or "down" correction pulses. When flip-flops 1 and 2 have opposite outputs, correction pulses are needed, and there is an output from circuit *a*. A half cycle prior to this instant, flip-flop 3 samples the signal, and *exclusive or* circuit *b* determines whether an "up" or "down" correction pulse is needed. The inputs to *b* are the samples taken at the beginning of time interval 0 and remembered on flip-flop 1 as well as the samples taken either at the beginning of time interval 1 or 3 and remembered on flip-flop 3. If this comparison is made during time interval 0, the secondary sample obtained at the beginning of time interval 3 is used. If the comparison occurs during time interval 2, the secondary sample at the beginning of time interval 1 is used. When the two samples are the same, the "down" correction pulse *and* gate has an input. When the two samples are different, the "up" correction pulse *and* gate has an input. The "correction pulse readout time indicator" line has an output only during time intervals 0 and 2, so that correction pulses can appear only in these intervals. The correction pulses are sent to an integrator which controls the oscillator.

## Notes:

1. When noise is present on the input signal the "up" and "down" correction pulses must be processed by additional circuitry which allows an output only when a certain minimum number of sequential "up" or "down" correction pulses are counted. With this addition, the system will operate effectively when the noise voltage is twice that of the true signal voltage.
2. The circuit may also be used as a sensing device to indicate whether a signal is present on one of several input lines.
3. Inquiries concerning this invention may be directed to:

Technology Utilization Officer
Goddard Space Flight Center
Greenbelt, Maryland, 20771
Reference: B65-10307

**Patent status:** NASA encourages the immediate commercial use of this invention. Inquiries about obtaining rights for its commercial use may be made to NASA, Code AGP, Washington, D.C., 20546.

Source: David Schaefer
(GSFC-268)

October 1965 Brief 65-10308

# NASA TECH BRIEF

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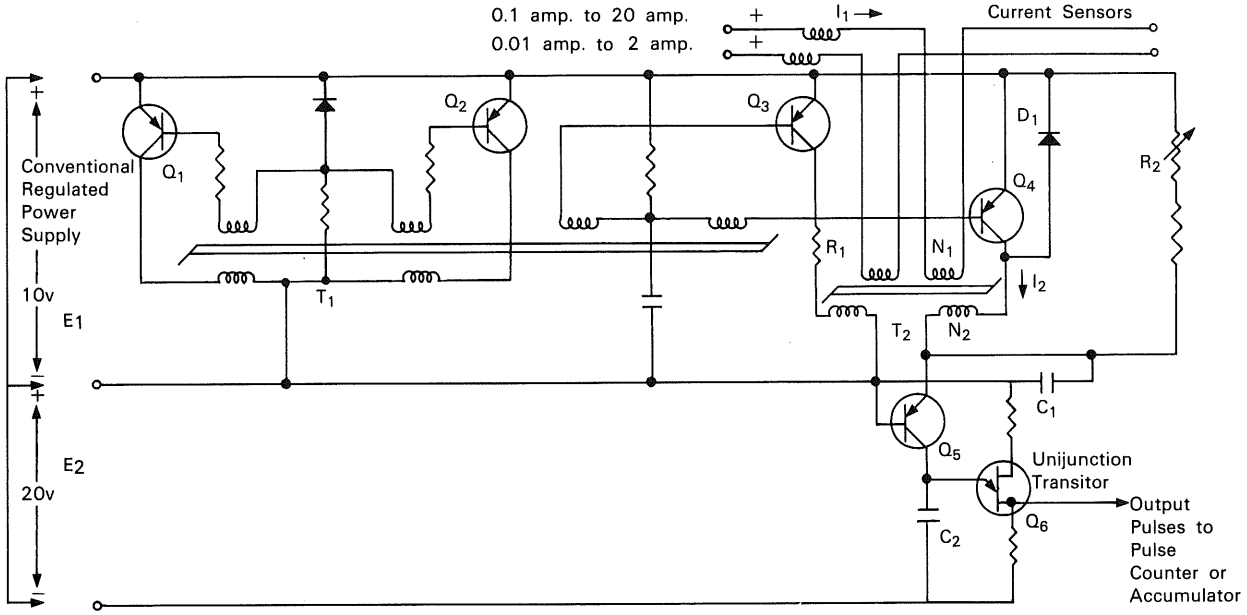
## Electronic Ampere-Hour Integrator is Accurate to One Percent



**The problem:** Normally, ampere-hour integrators are mechanical devices, such as a ball and disc, which operate on information from a recorder. They have the inherent disadvantages of large physical size, dependence on the accuracy of the recorder, and mechanical wear which results in drift requiring frequent calibration.

**The solution:** A solid state, dual-range electronic ampere-hour integrator based on current-to-frequency conversion. The integrator operates on low power, and is accurate to within 1 percent from a 10 milliampere rate to a 20 ampere rate.

**How it's done:** The circuit shown is based on the reflected impedance of transformer $T_2$. A square wave oscillator circuit, using transistors $Q_1$ and $Q_2$, alternately drives transistors $Q_3$ and $Q_4$. Each time transistor $Q_3$ is turned "on", saturable transformer $T_2$ is reset to its negative saturation state. When transistor $Q_4$ is turned "on", the reflected current from the sensing circuit causes a proportional current to flow through transistor $Q_5$ to charge pulse rate capacitor $C_2$. The reflected current $I_2$ is directly proportional to the input current $I_1$ and is given by $I_2 = I_1\ (N_1/N_2)$ where:

$I_1$ = current to be sensed
$I_2$ = reflected current
$N_2$ = primary turns of $T_2$
$N_1$ = secondary turns of $T_2$

When $C_2$ has accumulated sufficient charge to cause

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unijunction transistor $Q_6$ to conduct, an output pulse is applied to the accumulator and, simultaneously, $C_2$ is discharged. Thus the circuit converts the current rate to pulse rate. The accumulator indicates the total ampere-hours and consists of a simple counter. The magnetizing current required by $T_2$ during conduction of $Q_4$ causes an undesirable error at low current levels; however, its effects can be minimized by utilizing the stored energy of the square-loop core. Energy is stored during conduction of $Q_3$ and its level is determined by $R_1$. When the driving source to $Q_3$ is removed the energy is transferred to the capacitor $C_1$ via diode $D_1$ and the power source $E_1$. Thus capacitor $C_1$ is capable of supplying the required magnetizing current during conduction of $Q_4$. Resistor $R_2$ is adjusted to drain off the excess stored charge on $C_1$.

**Notes:**

1. This device can be used to measure the ampere-hour capacity of batteries.
2. By adding series resistors to the current-sensing coil the output pulse rate will be directly proportional to the voltage being sensed, thus making the circuit a voltage-to-frequency converter.
3. Addition of an accumulator to the voltage-to-frequency converter makes the circuit a volt-time integrator.
4. Inquiries concerning this invention may be directed to:

Technology Utilization Officer
Goddard Space Flight Center
Greenbelt, Maryland, 20771
Reference: B65-10308

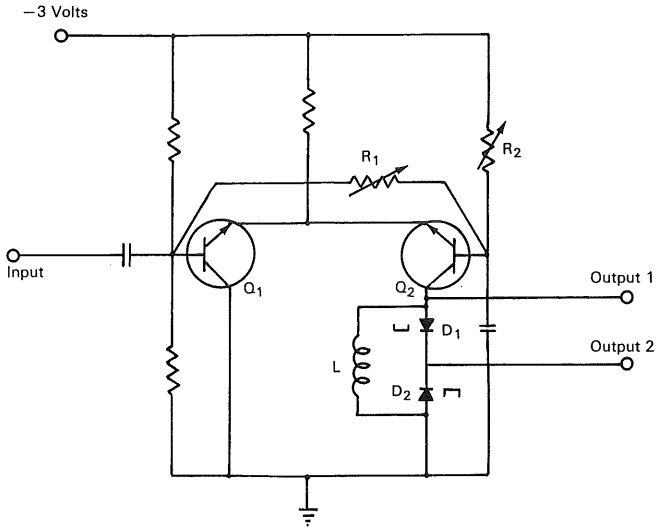
**Patent status:** NASA encourages the immediate commercial use of this invention. Inquiries about obtaining rights for its commercial use may be made to NASA, Code AGP, Washington, D.C., 20546.

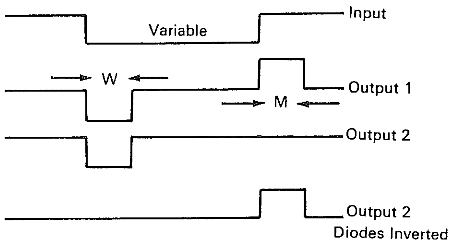
Source: John Paulkovich
(GSFC-203)

October 1965 Brief 65-10310

# NASA TECH BRIEF

## Threshold Detector Produces Narrow Pulses at High Repetition Rates





**The problem:** To generate fixed-duration output pulses in the nanosecond range at input pulse repetition rates up to 5 megacycles whenever the input pulse amplitude is greater than a fixed threshold level. Prior art required gating and differentiating to produce trigger pulses to drive monostable or blocking oscillators. Such circuitry is complex, consumes a relatively large amount of power, and does not readily lend itself to use with high repetition rate inputs.

**The solution:** A solid-state device consisting of two tunnel diodes back-to-back in parallel with an inductance driven by a constant-current generator. Input pulses of variable width in the nanosecond range yield output pulses of fixed width. The circuit produces pulse repetition rates in the megacycle range and exhibits low power drain.

**How it's done:** Stages $Q_1$ and $Q_2$, together with tunnel diodes $D_1$ and $D_2$, form a threshold detector circuit in which the voltage across $D_1$ switches to its high-voltage state and produces output pulse W whenever the input exceeds the threshold level. Diode $D_2$ remains in its low-voltage state and presents a very low impedance. Current through inductance L, starting at zero due to its initial high impedance, will increase with time, thereby decreasing current flow through $D_1$ and $D_2$ Voltage across $D_1$ will decrease to near zero and $D_1$ will switch to its low-voltage state at a point in time when most of the current is flowing through L, which presents such low impedance that the output voltage will be approximately zero for the remainder of the input pulse. As the input pulse reaches zero, current through L now flows through $D_1$ and $D_2$ in

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the opposite direction causing $D_2$ to switch to its high-voltage state and produce output pulse M as $D_1$ remains in its low-voltage state. Threshold level in $D_1$ and $D_2$ is set by adjusting $R_1$ and $R_2$. The value of L determines output pulse width. The circuit configuration shown yielded 50 nanosecond pulses for an inductance of 56 microhenries.

**Notes:**

1. All possible combinations of output pulse polarity relative to pulse input polarity are available by arrangement of $D_1$ and $D_2$ and the input polarity.
2. Because the output pulses occur at the rise and/or fall times of the input pulses, the circuit is useful as a zero-crossing detector.
3. Inquiries concerning this invention may be directed to:

Technology Utilization Officer
Goddard Space Flight Center
Greenbelt, Maryland, 20771
Reference: B65-10310

**Patent status:** NASA encourages the immediate commercial use of this invention. Inquiries about obtaining rights for its commercial use may be made to NASA, Code AGP, Washington, D.C., 20546.

Source: Norman M. Garrahan
(GSFC-383)

October 1965 Brief 65-10311

# NASA TECH BRIEF

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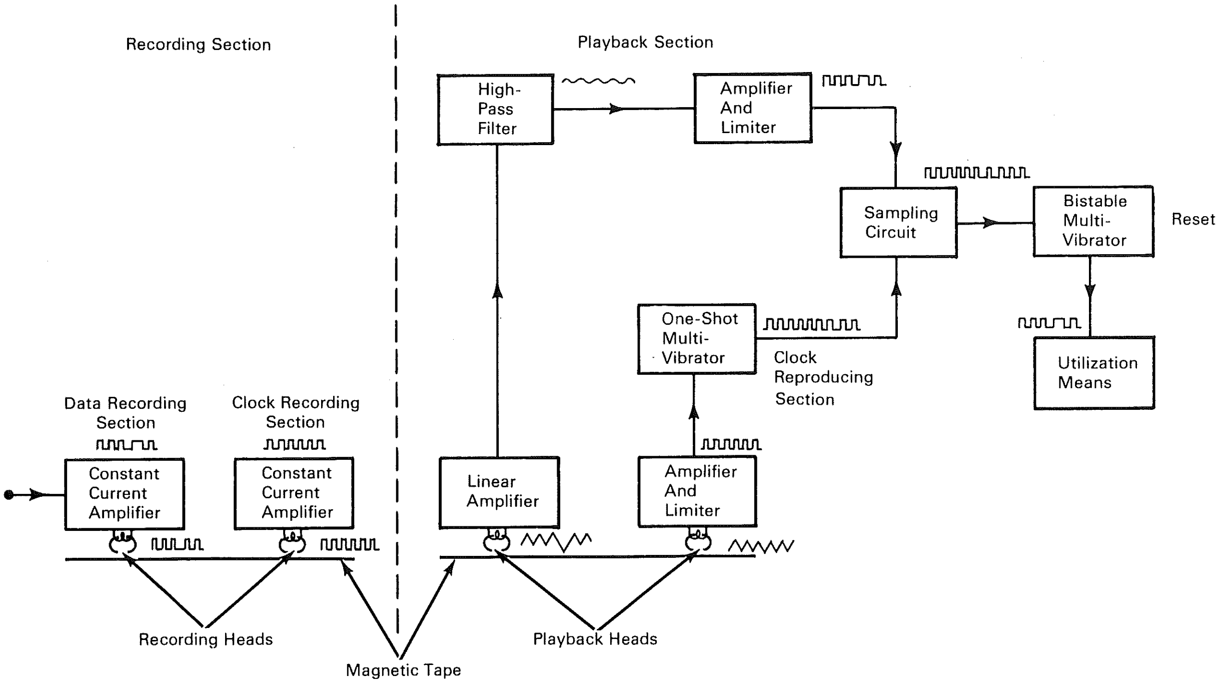
## PCM Magnetic Tape System Efficiently Records and Reproduces Data


Recording Section
Playback Section
High-Pass Filter
Amplifier And Limiter
Sampling Circuit
Bistable Multi-Vibrator
Reset
One-Shot Multi-Vibrator
Clock Reproducing Section
Utilization Means
Data Recording Section
Clock Recording Section
Constant Current Amplifier
Constant Current Amplifier
Linear Amplifier
Amplifier And Limiter
Recording Heads
Playback Heads
Magnetic Tape

**The problem:** To design a reliable, precision PCM (pulse code modulated) magnetic tape recording and reproducing system that achieves a high packing density on the tape and provides a symmetrical reproduction of the recorded signal.

**The solution:** Utilizing the split-phase PCM technique, the gap width of the playback head is matched to approximately one half the wavelength of the prf (pulse repetition frequency). The playback head then has the characteristics of a low-pass filter and accordingly provides an output signal that is an integral of the recorded square waveform. When the playback head gap width equals one half the recorded wavelength, maximum head output voltage is obtained. This is also the condition for reliable reproduction of the recorded signal near the upper frequency limit of the playback head. Clock signal circuitry is used to provide high pulse symmetry.

**How it's done:** The recording system consists of a data recording section and a clock signal recording section. Both data and clock signals are fed into constant-current amplifiers (which are essentially insensitive to frequency variations). The outputs from these

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amplifiers are coupled to recording heads which induce the magnetic patterns (a data track and a clock track) on the tape.

The playback system also has two sections, one for data reproduction and one for clock signal reproduction. Upon playback, the magnetic data and clock tracks generate voltages in their respective playback heads. The output voltage from the data playback head is amplified by a linear amplifier, and the resultant signal is fed to a high-pass filter whose low-frequency cutoff point is approximately equal to the prf. The output signal from this filter is a derivative of the signal from the data playback head. The amplifier-limiter amplifies the filtered signal and clips it to form a square wave of substantially the same shape as that of the originally recorded PCM signal. The clock reproducing section, by means of an amplifier-limiter and a one-shot multivibrator, generates a unidirectional signal at a phase difference of 90° with respect to the amplifier-limiter signal. The sampling circuit receives these signals and triggers the multivibrator to produce an output signal that, except for a 90° phase difference, is an exact duplicate of the originally recorded PCM data.

**Notes:**

1. The clock circuitry may be omitted in situations where symmetry and high timing accuracy are not required.
2. The clock track can be eliminated by synchronizing an oscillator to the playback data repetition frequency to derive the sampling pulses.
3. The basic system (with or without clock sections) may be modified to record and reproduce more than one data track by incorporating a data recording section and a data playback section for each additional track to be accommodated.
4. A single head, constructed in the manner described for the playback head, can be used to perform the recording and playback functions.
5. Should it become desirable to compensate for any phase shift that may result in the system, a phase shifting network can be inserted between the one-shot multivibrator and each sampling circuit.
6. Inquiries concerning this invention may be directed to:

Technology Utilization Officer
Goddard Space Flight Center
Greenbelt, Maryland, 20771
Reference: B65-10311

**Patent status:** NASA encourages the immediate commercial use of this invention. It is owned by NASA, and a patent application has been filed. When patented, royalty-free nonexclusive licenses for its commercial use will be available. Inquiries concerning license rights should be made to NASA, Code AGP, Washington, D.C., 20546.

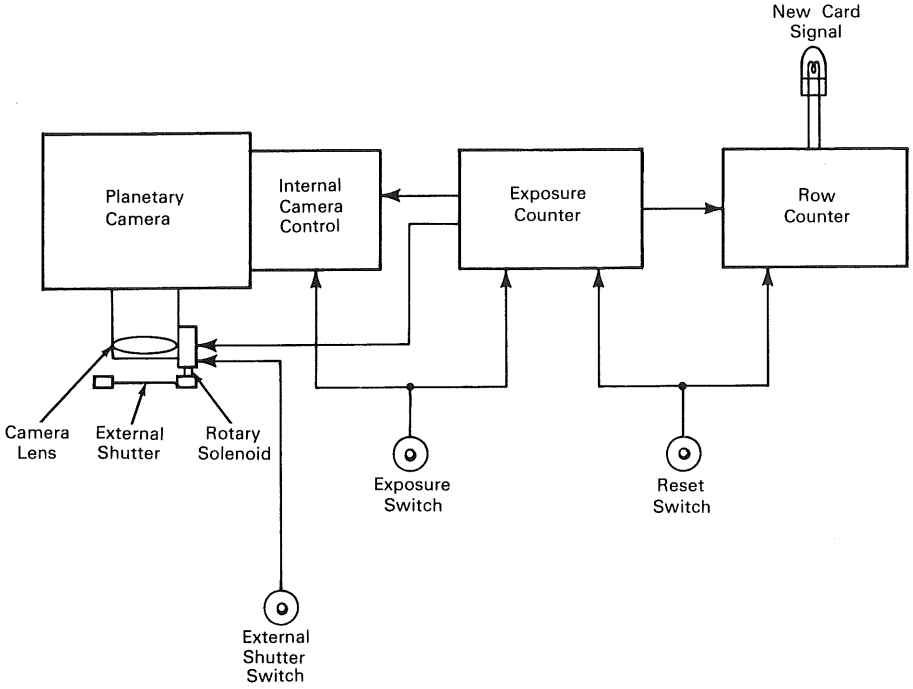
Source: Pleasant T. Cole
(GSFC-375)

October 1965

Brief 65-10313

# NASA TECH BRIEF

## Planetary Camera Control Improves Microfiche Production



**The problem:** Preparing microfiche (microphotograph transparencies in card format) with a conventional planetary camera requires time-consuming manual monitoring of the operations and can involve high error incidence. The operator must keep a count of the number of frames exposed per row, the number of rows exposed per card, determine whether or not a masthead belongs at the top of the card (this determines the number of exposed rows), and cover the lens to produce unexposed film for cutting in order to attach each row to the microfiche frame.

**The solution:** An automatic control system that provides the necessary blank end-of-row exposures for cutting and signals completion of a card so that the appropriate legend for the following card may be photographed next.

**How it's done:** The exposure switch advances the exposure counter and activates the internal camera control to trip the shutter and advance the film. When the counter reaches six (the number of two-frame exposures per row), it advances the row counter, operates the rotary solenoid to place the external shutter in front of the lens, operates the camera shutter and film advance twice, retracts the external shutter, and resets the exposure counter to zero.

For follow cards, when the row counter reaches six, the new card signal lights to tell the operator

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that the next exposure will be the first frame of a new card. This enables the operator to place the new card identifying information before the camera. If the card being made up is the first card of the document, a switch on the row counter is set so that the fifth row will be the last, in order that a masthead may be stripped into the card. At the end of a document, the external shutter manual switch is depressed and held along with the exposure switch long enough to complete the row and provide an interdocument space. Pushing the reset returns both counters to zero for the start of the next document.

**Notes:**

1. The application of these techniques should be of interest to organizations producing microrecords.
2. Inquiries concerning this invention may be directed to:

   Technology Utilization Officer
   National Aeronautics and Space Administration
   Code ATU
   Washington, D.C., 20546
   Reference: B65-10313

**Patent status:** NASA encourages the immediate commercial use of this invention. Inquiries about obtaining rights for its commercial use may be made to NASA, Code AGP, Washington, D.C., 20546.

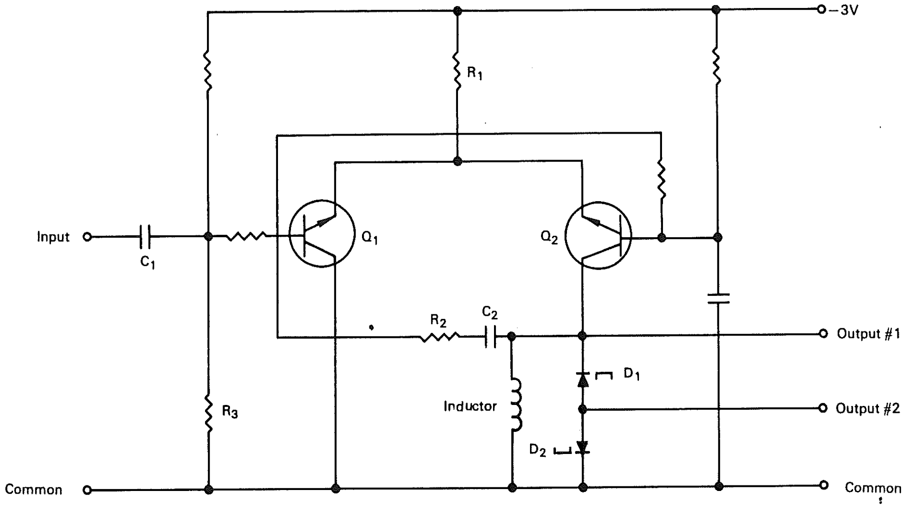
Source: W. L. Chesterson and
E. Brien Lewis of
Documentation Incorporated
under contract to NASA
(HQ-1 and 5)

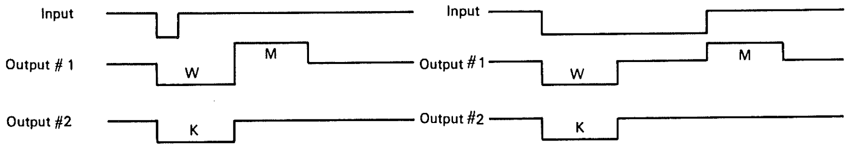
October 1965 Brief 65-10314

# NASA TECH BRIEF

NASA Tech Briefs are issued by the Technology Utilization Division to summarize specific technical innovations derived from the space program. Copies are available to the public from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia, 22151.

## Hybrid Circuit Achieves Pulse Regeneration with Low Power Drain





Input Pulse Narrower than "W" Input Pulse Wider than "W"

**The problem:** To provide a solid-state, low power drain pulse regenerator circuit capable of output pulse widths as narrow as 100 nanoseconds and independent of input pulse widths. Present circuits differentiate the input pulse, triggering a pulse generator for regeneration, and use gates and timing circuits for frequency limiters and gated oscillators. This circuitry is relatively complex and is characterized by heavy power drain when working with narrow pulses.

**The solution:** A hybrid tunnel diode-transistor circuit forming a solid-state, low power drain pulse regenerator, frequency limiter, or gated oscillator.

**How it's done:** The two transistors form an emitter-follower differential amplifier. Transistor $Q_1$ is normally biased on and $Q_2$ is normally biased off. Bias current through $R_1$ is about 1.5 times that required to trigger tunnel diodes $D_1$ and $D_2$. A negative input pulse turns $Q_1$ off and $Q_2$ on, thus triggering $D_2$ into its high-voltage state. As $Q_2$ is initially turned on, the inductor presents a high impedance, channeling the $Q_2$ collector current through $D_1$ and $D_2$. When current through the inductor increases sufficiently, $D_2$ returns to its low-voltage state and this produces output *W* whose width is determined by the value of the inductor. Capacitor $C_2$ and resistor $R_2$ form a feedback

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loop to hold $Q_1$ biased off. When the input pulse width is smaller than $W$, the feedback voltage falls to zero and resets the amplifier ($Q_1$ on and $Q_2$ off). Continued current flow through the inductor causes $D_1$ to remain in the high-voltage state until the current decays, at which time $D_1$ returns to its low-voltage state, yielding output pulse $M$ (width of $M \approx$ width of $W$). If the input pulse is wider than $W$, the input signal is still present when the feedback voltage drops to zero, thus sustaining current flow through the inductor. The signal pulse $K$ is generated at output number 2 for each input pulse, independent of input pulse width.

**Notes:**

1. When the feedback voltage exceeds the input voltage the circuit will function as either a pulse normalizer or a frequency limiter. If the input pulse period is greater than time $W + M$, the circuit functions as a pulse normalizer. If the input pulse period is less than time $W + M$, the circuit functions as a frequency limiter.
2. If the circuit is direct coupled ($C_1$ replaced by a resistor), it will function as a gated oscillator. In this mode, $R_3$ should be replaced by a tunnel diode to limit input voltage.
3. Input-output polarity combinations are only limited by the choice of NPN or PNP transistors plus connection polarity of the tunnel diodes.
4. Inquiries concerning this invention may be directed to:

Technology Utilization Officer
Goddard Space Flight Center
Greenbelt, Maryland, 20771
Reference: B65-10314

**Patent status**: NASA encourages the immediate commercial use of this invention. Inquiries about obtaining rights for its commercial use may be made to NASA, Code AGP, Washington, D.C., 20546.

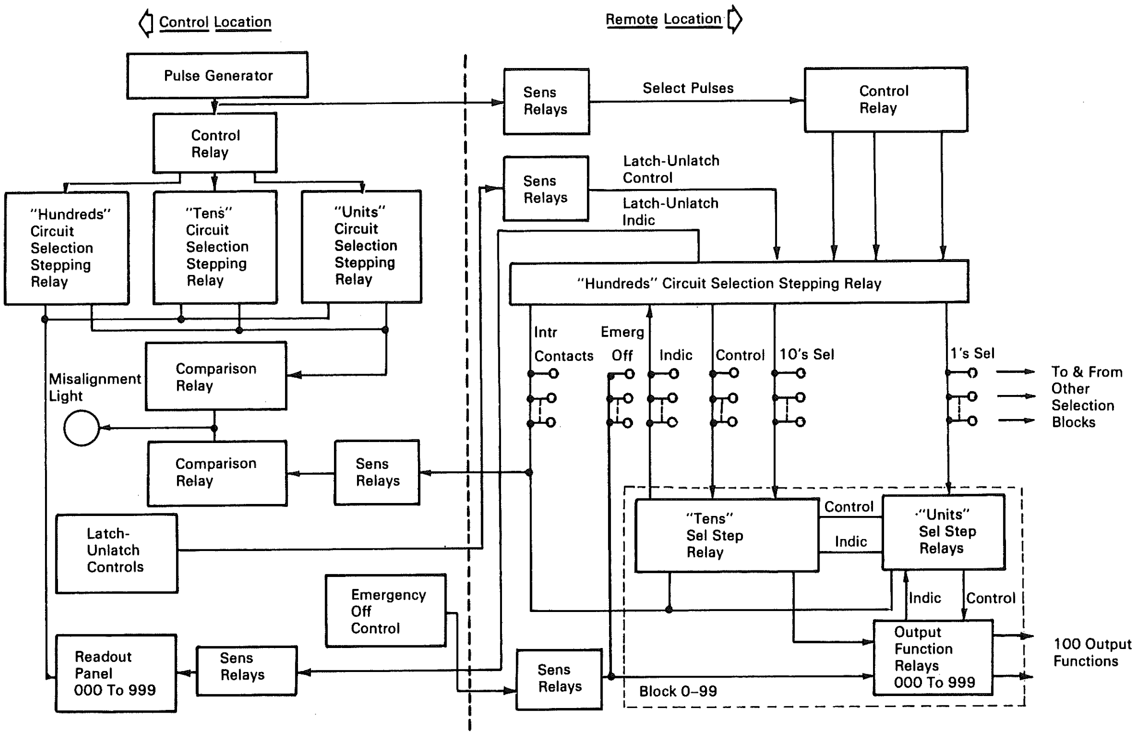
Source: Ciro A. Cancro
(GSFC-382)

October 1965 Brief 65-10318

# NASA TECH BRIEF

NASA Tech Briefs are issued by the Technology Utilization Division to summarize specific technical innovations derived from the space program. Copies are available to the public from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia, 22151.

## Remote Control Electrical Switching System Has 1000-Output Capability


Control Location
Remote Location
Pulse Generator
Control Relay
"Hundreds" Circuit Selection Stepping Relay
"Tens" Circuit Selection Stepping Relay
"Units" Circuit Selection Stepping Relay
Misalignment Light
Comparison Relay
Comparison Relay
Sens Relays
Latch-Unlatch Controls
Emergency Off Control
Readout Panel 000 To 999
Sens Relays
Sens Relays
Select Pulses
Control Relay
Sens Relays
Latch-Unlatch Control
Latch-Unlatch Indic
"Hundreds" Circuit Selection Stepping Relay
Intr Contacts
Emerg Off
Indic
Control
10's Sel
1's Sel
To & From Other Selection Blocks
"Tens" Sel Step Relay
Control
Indic
"Units" Sel Step Relays
Indic
Control
Output Function Relays 000 To 999
100 Output Functions
Sens Relays
Block 0–99

BLOCK DIAGRAM FOR 100 OUTPUT

**The problem:** To design a versatile remote control system using a minimum of interconnections between the control location and the remote location to reduce installation and maintenance costs.

**The solution:** An electromechanical remote control command system with a capacity of 1000 individual on-off functions, using only seven pairs of telephone-type lines for interconnection. The system provides either momentary operation or selective latching and unlatching operation of any of 1000 possible output function relays. Automatic verification circuits provide a positive indication of the output status to ensure error-free operation.

**How it's done:** A transistorized flip-flop pulse generator and stepping relay combination at the control location provides the control signals for the system. The generator is controlled by ten pushbuttons and supplies pulses required to activate the circuit selection stepping relays. Sensitive relays at the remote location receive these pulses. Pulses are fed through

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control relays, at both locations, to the circuit selection relays. The control relays step once for each group of pulses and feed pulses first to the "hundreds" relays, then to the "tens" relays, and finally to the "units" relays. The fourth position of the control relay automatically resets the selection relays to their zero position. At the remote location, the "hundreds" relay selects one of the ten possible blocks of 100 output relays. The "tens" and "units" relays then act in a cross-bar manner to select the particular output relay in the selected block. An indicator light at the remote location is provided for each output function.

As the selection operation occurs, two comparison stepping relays at the control location are activated to verify correct selection relay operation. If the control location does not agree with the remote location, a light at the control location indicates the misalignment. An operator can then reset all of the output relays by means of pushbuttons in the emergency off control. A readout panel at the control location indicates the status (latched or unlatched) of all the output relays.

**Notes:**

1. The block diagram shows the functional elements for 100 output relays. The capacity of the system can be increased, in increments of 100, to the full capacity of 1000 output functions.
2. Inquiries concerning this invention may be directed to:

Technology Utilization Officer
Marshall Space Flight Center
Huntsville, Alabama, 35812
Reference: B65-10318

**Patent status:** NASA encourages the immediate commercial use of this invention. It is owned by NASA and inquiries about obtaining royalty-free rights for its commercial use may be made to NASA, Code AGP, Washington, D.C., 20546.

Source: International Business Machines under
contract to Marshall Space Flight Center
(M-FS-380)

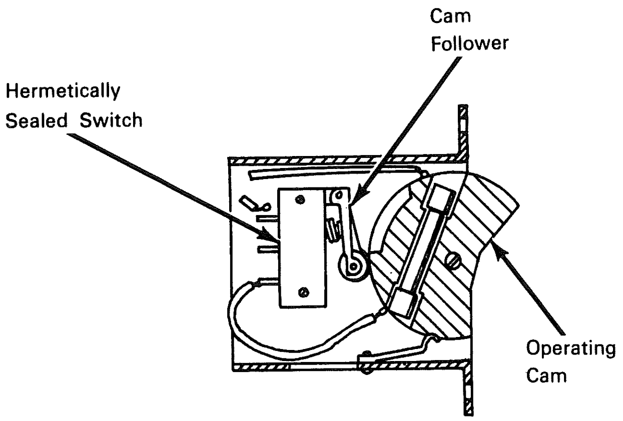
October 1965

Brief 65-10322

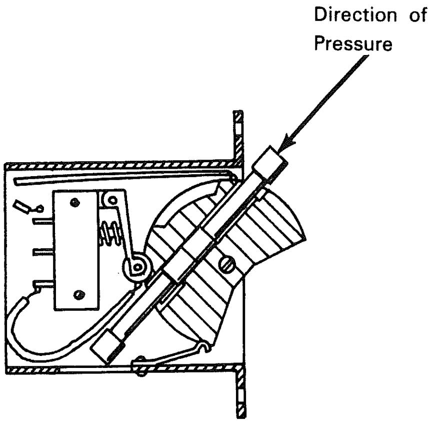
# NASA TECH BRIEF

NASA Tech Briefs are issued by the Technology Utilization Division to summarize specific technical innovations derived from the space program. Copies are available to the public from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia, 22151.

## Cam-Operated Limit Switch Features Safe Fuse Replacement



NEAR SWITCH CLOSED



"REPLACE FUSE" POSITION

**The problem:** To design a multiple-limit, fused switching arrangement that is easily operated and permits fuse replacement without danger of a spark or arcing.

**The solution:** Two hermetically sealed, short travel, limit switches (only one is visible in the figure) wired in parallel circuits and actuated by manually operated cams containing the circuit fuses. By moving the cams to a certain position, the fuses are open circuited and positioned for quick, safe replacement. The cams can be fitted with fuses of different current capacity so that different load conditions may be met by simply switching one in and the other out.

**How it's done:** A pair of manually positioned cams, mounted on a common axis, operates the switches. In the off position, both of the parallel circuits are opened. In a second position, one of the parallel circuits containing a fuse of given rating is closed and the other circuit is open. In a third position, the previous situation is reversed so that a fuse of different rating is in the circuit. A fourth position, called the "replace fuse" position opens both parallel circuits and positions both fuses so that they can be quickly and safely replaced by inserting new fuses that force the old fuses out of the cam blocks.

**Notes:**

1. This switching device, because of its simple design, could readily be mass produced.
2. This invention would be useful in paint spray booths, cracking plants, explosives factories, or any place involved with the switching of electrical power in an explosive or combustible environment.

**Patent status:** Title to this invention, covered by U.S. Patent No. 3,123,692, has been waived under the provisions of the National Aeronautics and Space Act (42 U.S.C. 2457 (f)) to the McDonnell Aircraft Corporation, Box 516, St. Louis, Missouri, 63166.

Source: George J. Weber of the McDonnell
Aircraft Corporation under contract
to Manned Spacecraft Center
(MSC-218)
Category 01

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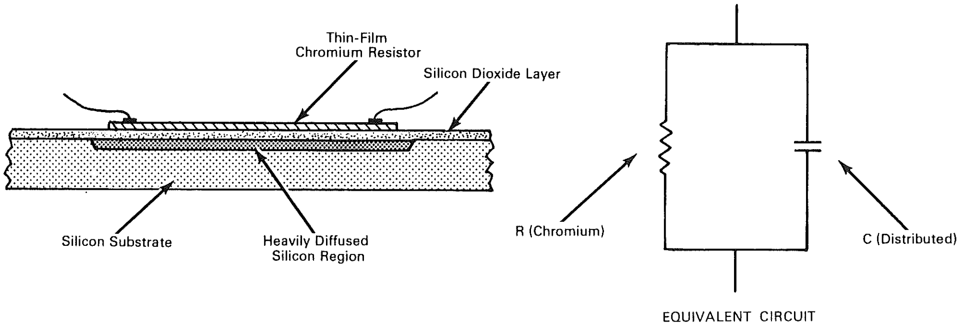
October 1965 Brief 65-10305

# NASA TECH BRIEF

NASA Tech Briefs are issued by the Technology Utilization Division to summarize specific technical innovations derived from the space program. Copies are available to the public from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia, 22151.

## Thin-Film Resistors Used in Functional Electronic Blocks



**The problem:** Diffused resistors which have been used in R-C tank circuits in a solid state electronic block have a distributed parallel capacitance associated with the depletion layer of the p-n junction. Small capacitances in this R-C combination produce long rise times, while large values cause either peaking or ringing, depending on the associated inductance of the circuit. If diffused resistors are used, an optimum parallel capacitance cannot be obtained for many circuit applications requiring a resistance greater than 50K ohms and a capacitance less than 100 pf.

**The solution:** Use vapor-deposited thin-film resistors instead of diffused resistors in the functional electronic block.

**How it's done:** In the case of a silicon dioxide/silicon system, a chromium thin-film resistor is vapor-deposited over a thin silicon dioxide layer grown over a heavily diffused p or n silicon region. The distributed parallel capacitance is then controlled by the thickness of the silicon dioxide layer and the area of the chromium film. To lower the capacitance, this area is kept at a minimum consistent with the resistivities obtainable with chromium films and the thickness of the silicon dioxide layer is increased. The thicker layer also improves the reliability and reproducibility of the capacitor. If the thickness of this layer is varied from 200 to 10,000 angstroms, the capacitance will correspondingly vary from 0.9 to 0.02 pf per square mil. For a chromium film 1 mil by 100 mils with a "resistivity" of 1K ohm per square mil, the resistance will be 100K ohms and the capacitance will range from 90 to 2.0 pf as the oxide thickness is varied from 200 to 10,000 angstroms.

**Notes:**

1. By utilizing the distributed parallel capacitance associated with the diffused region under the silicon dioxide layer, both high- and low-value capacitors can be paralleled. Since the capacitance is internally connected, two external connections are eliminated.
2. The above principle can be applied using any thin-film metal with a sufficiently high resistivity on a variety of semiconductors to control the R-C characteristics in functional electronic blocks.

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3. Inquiries concerning this innovation may be directed to:

   Technology Utilization Officer
   Goddard Space Flight Center
   Greenbelt, Maryland, 20771
   Reference: B65-10305

**Patent status:** NASA encourages commercial use of this innovation. No patent action is contemplated by NASA.

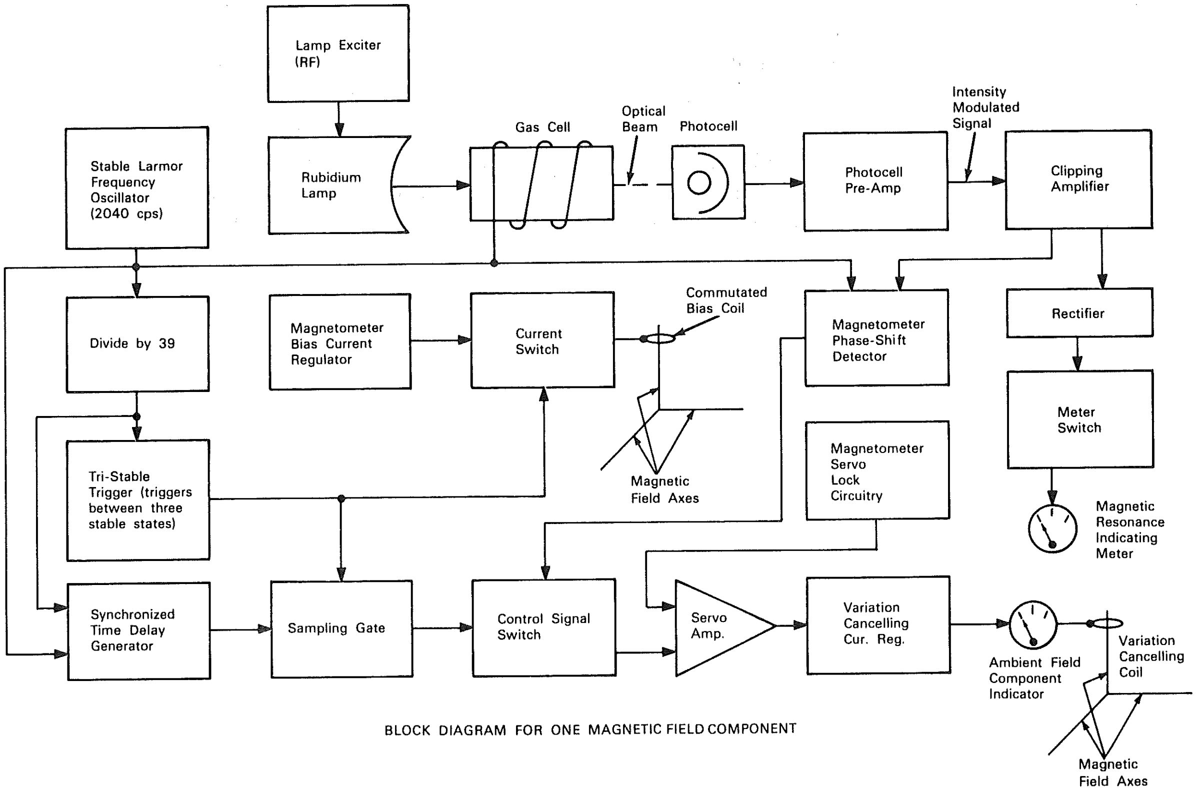
Source: Westinghouse Electric Corporation
under contract to
Goddard Space Flight Center
(GSFC-380)

October 1965 Brief 65-10315

# NASA TECH BRIEF

NASA Tech Briefs are issued by the Technology Utilization Division to summarize specific technical innovations derived from the space program. Copies are available to the public from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia, 22151.

## Magnetometer Measures Orthogonal Components of Magnetic Fields


Lamp Exciter (RF)
Stable Larmor Frequency Oscillator (2040 cps)
Rubidium Lamp
Gas Cell
Optical Beam
Photocell
Intensity Modulated Signal
Photocell Pre-Amp
Clipping Amplifier
Commutated Bias Coil
Divide by 39
Magnetometer Bias Current Regulator
Current Switch
Magnetometer Phase-Shift Detector
Rectifier
Meter Switch
Magnetic Field Axes
Magnetometer Servo Lock Circuitry
Tri-Stable Trigger (triggers between three stable states)
Magnetic Resonance Indicating Meter
Synchronized Time Delay Generator
Sampling Gate
Control Signal Switch
Servo Amp.
Variation Cancelling Cur. Reg.
Ambient Field Component Indicator
Variation Cancelling Coil
Magnetic Field Axes

BLOCK DIAGRAM FOR ONE MAGNETIC FIELD COMPONENT

**The problem:** To devise a magnetometer that will accurately measure the components of a low-strength magnetic field (such as that of the earth) in each of three mutually perpendicular directions.

**The solution:** A driven magnetometer employing the principle of magnetic resonance in optically pumped rubidium vapor. It incorporates a rubidium vapor cell (gas cell) surrounded by magnetic field bias coils disposed along the three axes of measurement. A phase detector generates a signal proportional to the magnitude and direction of the ambient magnetic field.

**How it's done:** A gas cell containing rubidium vapor is irradiated by a beam of optical resonance radiation from the rubidium vapor lamp, thus aligning the electron spins of the gas-cell atoms along the direction of the beam. The resultant net magnetic moment in the gas cell precesses about any steady ambient magnetic field at a frequency which varies accurately and sensitively with variations in the intensity

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(without regard to direction) of the magnetic field.

A known bias field is sequentially applied (commutated) to each of the three orthogonal bias coils, and the intensity modulation of the optical beam is detected by a photocell. Simultaneously, an alternating magnetic field is applied to the gas cell at a frequency equal to the Larmor magnetic resonance frequency of the gas cell atoms in the known bias field. The detected intensity modulation signal, after undergoing amplification and clipping, is compared to the alternating magnetic field signal by a phase detector during each cycle of the commutated bias field. If any ambient magnetic field (in addition to the known bias field) exists along a particular axis there will be a phase shift and the phase detector will generate a signal proportional to the magnitude of the ambient field vector.

The phase detector output is sequentially sampled by means of a three-state trigger and a sampling gate for each axis. The signal proportional to the phase shift (ambient magnetic field) drives a set of servocontrols which feed three variation-cancelling coils, thus reducing the total field to zero. The required current for each coil is a measure of the magnetic field component along each axis.

**Notes:**

1. In order to eliminate noise, the commutator switching is made synchronous with the alternating magnetic field signal.
2. This magnetometer should be useful in the measurement of magnetic fields where accurate three-component data are required. Specific applications include earth-field compensation for magnetic test coils and studies of magnetic anomalies in the earth's magnetic field.
3. Inquiries concerning this invention may be directed to:

Technology Utilization Officer
Goddard Space Flight Center
Greenbelt, Maryland, 20771
Reference: B65-10315

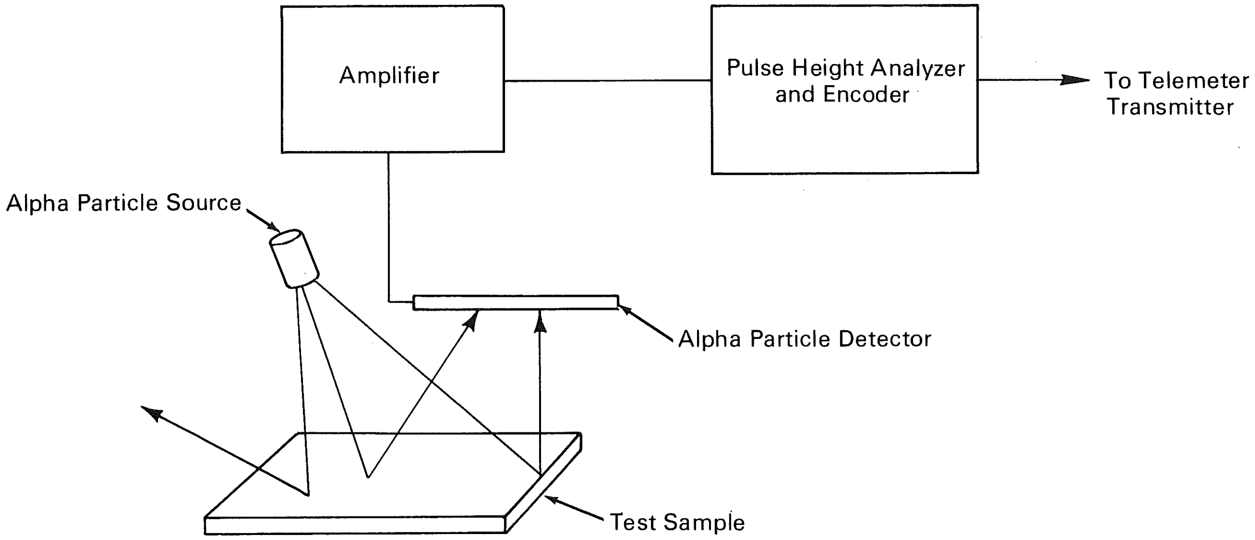
**Patent status:** NASA encourages the immediate commercial use of this invention. Inquiries about obtaining rights for its commercial use may be made to NASA, Code AGP, Washington, D.C., 20546.

Source: Spectra Physics under contract to
Goddard Space Flight Center
(GSFC-395)

October 1965 Brief 65-10317

# NASA TECH BRIEF

## Instrument Performs Nondestructive Chemical Analysis; Data Can Be Telemetered



**The problem:** Devising a lightweight instrument for nondestructive chemical analysis of surfaces. The instrument must automatically perform the analysis and provide the resultant data in the form of electronic signals which can be transmitted to remote sites. Such an instrument was particularly required for chemical analysis of lunar and planetary constituents and transmission of the data via telemetry to receiving stations on the earth.

**The solution:** An instrument employing simplified solid-state nuclear particle detectors in conjunction with a source of charged nuclear particles and an electronic pulse-height analyzer. The scattering of the charged particles from the atomic nuclei in the sample result in characteristic spectra.

**How it's done:** For relatively low-energy particles, such as alpha particles from the usual radioactive sources, and for those elements that are heavier than aluminum, the large-angle scattering of heavy charged particles is primarily Rutherford scattering. For light elements such as carbon and oxygen, and particularly with rather high-energy alpha particles such as those from $Cm^{244}$, nuclear effects enhance the scattering above that predicted from pure Rutherford scattering. For other light elements, such as nitrogen and fluorine, protons from (alpha, proton) reactions can also be expected.

The analysis of solids (the top 1 to 100 microns) is best conducted in a vacuum. A monochromatic, collimated beam of charged particles (e.g., alpha particles from a thin radioactive source) bombards the surface

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of the sample. Some of the charged particles scattered from the atoms (Rutherford scattering) within the sample strike the surface of a small solid-state (surface-depletion-type) detector placed at a high scattering angle (160° average) approximately 3 centimeters above the surface of the sample. The amplified pulses from the detector are converted into a particle count-energy spectrum. This spectrum may be encoded and telemetered to give analytical information on the kinds and amounts of elements present in the test sample.

**Notes:**

1. Previous experimental detector systems described in the literature have employed cumbersome and complex magnetic spectrometers. The novelty of this instrument lies in the use of a simplified solid-state detector system. As designed for use in the analysis of planetary constituents, the entire instrument weighs approximately eight pounds.
2. With some modification the instrument can be adapted for nondestructive chemical analysis of surface films, gases, and solid samples in laboratories or in chemical process industries.
3. Further information concerning this innovation is described in "Chemical Analysis of Surfaces by Use of Large-Angle Scattering of Heavy Charged Particles", by Anthony Turkevich, *Science*, *134*, 672, 8 September 1961. Inquiries may also be directed to:

Technology Utilization Officer
Jet Propulsion Laboratory
4800 Oak Grove Drive
Pasadena, California, 91103
Reference: B65-10317

**Patent status:** NASA encourages commercial use of this innovation. No patent action is contemplated by NASA.

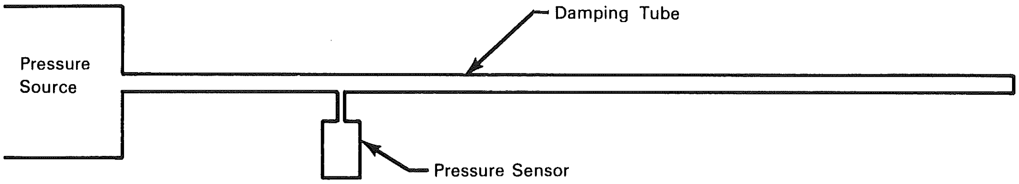
Source: Enrico Fermi Institute
for Nuclear Studies, University of
Chicago, under contract to
Jet Propulsion Laboratory
(JPL-SC-078)

October 1965 Brief 65-10301

# NASA TECH BRIEF

NASA Tech Briefs are issued by the Technology Utilization Division to summarize specific technical innovations derived from the space program. Copies are available to the public from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia, 22151.

## Remote Rapidly Varying Pressures Accurately Measured



**The problem:** To measure transient or rapidly varying fluid pressures in situations where it is not practicable to locate a pressure sensor at the point of disturbance. When a tube of finite length is used to transmit the pressure waves from the point of disturbance to a sensor at the other end of the tube, acoustic resonances introduce measurement errors. Although for such an arrangement resonances could be damped to a minimum level by using an extremely long tube, attenuation of the pressure wave would be excessive.

**The solution:** Use a transmitting-damping tube of sufficient length, with one end open to the pressure source and the other end closed. A pressure sensor is connected to a port in the tube at a point as close as practicable to the pressure source.

**How it's done:** The length of the tube is determined from the pressure parameters and maximum allowable resonant frequency. The cross-sectional area of the tube must be held constant over a length extending from the sensing point to a point downstream where the attenuation is sufficiently high. There will be some attenuation of the pressure wave as it travels from the pressure source to the sensor and also a transit-time delay. The errors from these causes, however, will be less than the errors caused by resonances in a tube terminated at the sensor.

**Notes:**

1. Application of this system is indicated for measurement of remote dynamic gas pressures at frequencies above 100 cps. It has been used for sound-pressure measurements under conditions where the microphone could not be located at the point of disturbance.
2. The attenuation from the sensor to the capped end of the tube must be high enough to prevent an appreciable echo from returning to the sensor. The attenuation can be increased by adding damping material, tapering the tube, or making part of the tube of acoustic-absorbing material.
3. Inquiries concerning this innovation may be directed to:

   Technology Utilization Officer
   Flight Research Center
   P.O. Box 273
   Edwards, California, 93523
   Reference: B65-10301

**Patent status:** NASA encourages commercial use of this innovation. No patent action is contemplated by NASA.

Source: General Electric Company
under contract to
Flight Research Center
(FRC-28)
Categories 01, 02, 05

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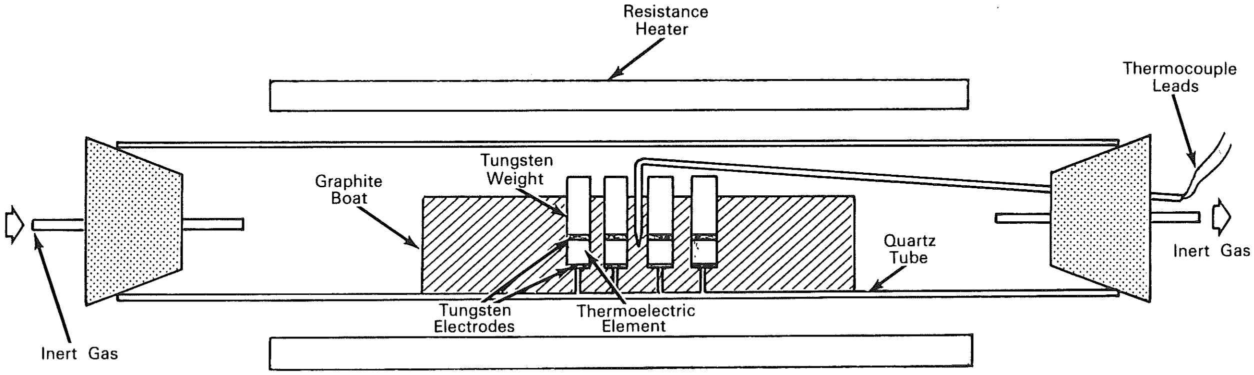
October 1965 Brief 65-10309

# NASA TECH BRIEF

## Thermoelectric Elements Diffusion-Bonded to Tungsten Electrodes



**The problem:** To bond lead telluride and lead telluride–tin telluride thermoelectric elements to tungsten electrodes. The bond must have high strength and low electrical and thermal resistance.

**The solution:** The thermoelectric elements are bonded to the tungsten electrodes by a solid-state diffusion process.

**How it's done:** The components to be bonded are degreased in boiling propanol, followed by washing under ultrasonic agitation in a solution of a commercial detergent in deionized water, and successive rinsing with deionized water and boiling methanol. The cleaned components are air-dried and then polished on the surfaces to be bonded in a parallel lapping fixture using a series of silicon carbide grits and finally 1800-grit alumina. The polished surfaces to be bonded are carefully fitted together and placed into a graphite boat which is then enclosed in a quartz diffusion tube. Bonding is accomplished in an inert-gas atmosphere at a temperature of 840° to 850°C maintained for 20 minutes.

**Notes:**

1. This method has also been successfully used for bonding of tantalum electrodes to lead telluride thermoelectric elements.
2. The resulting bonds are nonmagnetic and have high strength and low electrical and thermal resistance.
3. A procedure for solid-state diffusion bonding of thoriated nickel is summarized in NASA Tech Brief B65-10220, Aug. 1965.
4. Inquiries concerning this innovation may be directed to:

   Technology Utilization Officer
   Goddard Space Flight Center
   Greenbelt, Maryland, 20771
   Reference: B65-10309

**Patent status:** NASA encourages commercial use of this innovation. No patent action is contemplated by NASA.

Source: TYCO Laboratories, Inc. under
contract to Goddard Space Flight
Center
(GSFC-346)

Categories 01, 03

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October 1965 Brief 65-10320

# NASA TECH BRIEF

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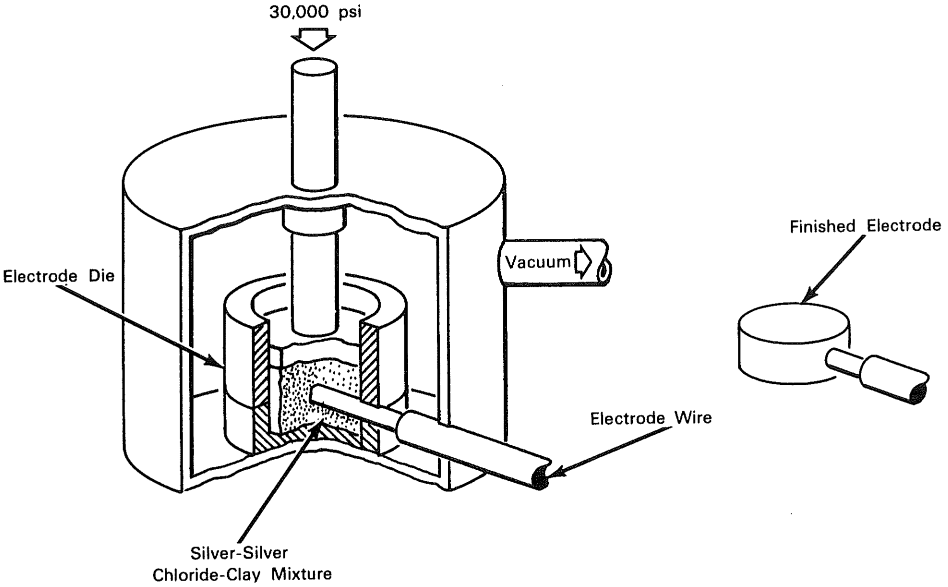
## Rugged Pressed Disk Electrode Has Low Contact Potential



**The problem:** To produce a biopotential electrode for monitoring physiological processes that exhibits low contact potential and resistance. The device must be sufficiently rugged to have long operating life even when used on a subject doing hard physical work.

**The solution:** A pressed-disk electrode of silver and silver chloride combined with bentonitic clay has a very low contact potential. The bentonitic clay affords a surface that permits use over extended periods without contact deterioration.

**How it's done:** The electrodes are prepared by combining 90 parts by weight of powdered silver with 10 parts of silver chloride. This mixture is then combined with bentonitic clay in a ratio of 95 parts Ag–AgCl to 5 parts clay. The mixture is placed in a specially constructed die in which the electrode lead wire has been properly positioned. The die is placed in a vacuum chamber and the mixture is subjected to a compressive force of 30,000 psi for a period of 30 to 60 seconds. The vacuum removes air and moisture that would react with the polymers to form oxidized compounds in the form of hard gels that adversely affect electrode potentials.

### Notes:

1. The disks produced by this method are uniformly porous and permeable; they exhibit contact potentials of about −5.7 microvolts and are impervious to bacteria or protein molecules.

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2. A related innovation is described in NASA Tech Brief 64-10025, May 1964. Inquiries may also be directed to:

   Technology Utilization Officer
   Manned Spacecraft Center
   P.O. Box 1537
   Houston, Texas, 77001
   Reference: B65-10320

**Patent status**: NASA encourages the immediate commercial use of this invention. Inquiries about obtaining rights for its commercial use may be made to NASA, Code AGP, Washington, D.C., 20546.

Source: J. L. Day, NASA and
Institute of Research and Instrumentation
under contract to Manned Spacecraft Center
(MSC-158)

October 1965

Brief 65-10300

# NASA TECH BRIEF

## Impurity Diffusion Process for Silicon Semiconductors Is Fast and Precise

**The problem:** To produce precision silicon semiconductor junctions economically by accelerated fabrication techniques. The present method involves a dopant-rich oxide that diffuses impurity atoms into a silicon wafer for a given time at a given temperature. Because the oxide is grown from the silicon wafer, impurities already in the silicon wafer may act as counterdopants to the desired impurities. Thus the concentration of the dopant in the oxide cannot be controlled. This method is also time consuming.

**The solution:** A process in which the oxide is deposited rather than grown on the silicon wafer and a controlled concentration of impurity atoms in gaseous form is simultaneously introduced into the reaction. This process is more accurate and requires much less time at elevated temperatures.

**How it's done:** A silicon dioxide ($SiO_2$) layer is deposited on the silicon wafer by either steam oxidation or thermal decomposition of $CO_2$ and $SiCl_4$ in the presence of hydrogen. A window is cut by photoengraving in the $SiO_2$ layer in the region where the junction is desired and a second $SiO_2$ layer is deposited in this region as a gaseous dopant is simultaneously introduced into the reaction. Dopants used are $B_2H_6$ (p type), $PH_3$ (n type), and $AsH_3$ (p type). The gas is metered into the reaction under much finer control than is possible with liquid or solid impurity sources. A shorter time at elevated temperatures is required and results in less migration of prior diffused impurities within the silicon.

**Notes:**

1. This invention should be of interest to manufacturers of semiconductor devices.
2. Inquiries concerning this invention may be directed to:

   Technology Utilization Officer
   Goddard Space Flight Center
   Greenbelt, Maryland, 20771
   Reference: B65-10300

**Patent status:** NASA encourages the immediate commercial use of this invention. Inquiries about obtaining rights for its commercial use may be made to NASA, Code AGP, Washington, D.C., 20546.

Source: Raymond M. McLouski and
Glenn W. Skouson of Westinghouse
Electric Corporation under contract
to Goddard Space Flight Center
(GSFC-397)

Categories 01, 05

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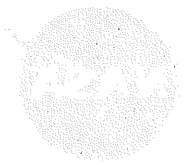
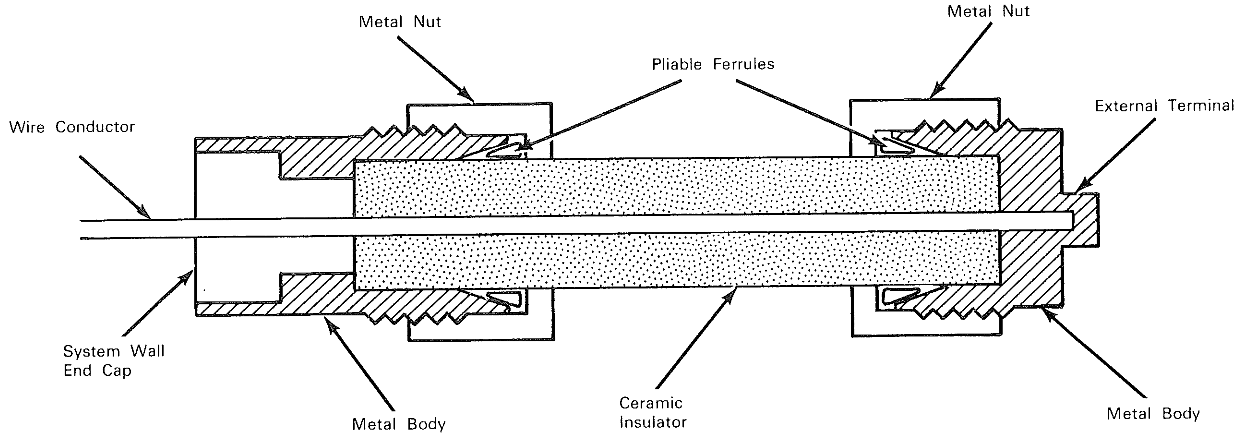


November 1965

Brief 65-10328

# NASA TECH BRIEF

## Feed-Through Connector Withstands High Temperatures in Vacuum Environment



**The problem:** To provide an electrical connection through the wall of a vacuum device and retain vacuum integrity through successive cycles of high temperature. Conventional ceramic-to-metal brazed connectors tend to become porous and lose their vacuum tightness after a relatively small number of heating cycles.

**The solution:** A feed-through connector so designed that its sealing action is augmented by any increase in temperature.

**How it's done:** The feed-through connector consists of an inner ceramic insulator, rigid metallic (e.g., kovar) end members in the form of bodies and mating nuts having a coefficient of expansion less than that of the ceramic insulator, and intermediate ferrules of pliable metal having a coefficient of expansion greater than the other parts. A wire through the center of the ceramic insulator provides the electrical path. This arrangement results in compression of the intermediate ferrules at elevated temperatures and assures the integrity of the vacuum seal.

**Note:** This connector would be useful in laboratories or shops where current must be introduced into an evacuated space subject to elevated temperature cycles.

**Patent status:** Title to this invention has been waived under the provisions of the National Aeronautics and Space Act (42 U.S.C. 2457 (f)), to the GCA Corporation, Bedford, Massachusetts.

Source: Wallace S. Kreisman of GCA
Corporation under contract to
Goddard Space Flight Center
(GSFC-442)

Category 01

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November 1965 Brief 65-10329

NASA TECH BRIEF

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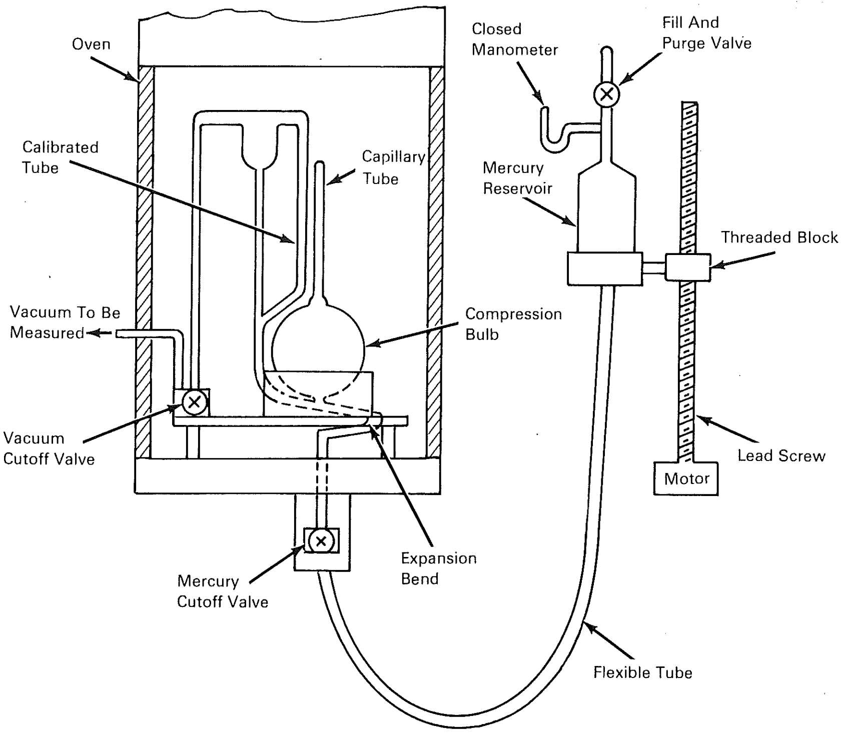
# Baking Enables McLeod Gauge to Measure in Ultrahigh Vacuum Range


Oven
Closed Manometer
Fill And Purge Valve
Calibrated Tube
Capillary Tube
Mercury Reservoir
Threaded Block
Vacuum To Be Measured
Compression Bulb
Vacuum Cutoff Valve
Lead Screw
Motor
Expansion Bend
Mercury Cutoff Valve
Flexible Tube

**The problem:** To effectively degas the glass walls of a conventional McLeod gauge in order to achieve measurements in the ultrahigh vacuum range. Conventional gauges use air pressure, $CO_2$ pressure, or a piston and cylinder to force the mercury from the reservoir into the gauge. In these arrangements contaminants come in contact with the mercury and impinge on the gauge walls so that only limited vacuums can be accurately measured. In the past, the glass walls have been degassed by means of a gas torch or electrical heating tape.

**The solution:** A closed system in which the mercury is forced into the gauge by gravity alone, and in which the gauge components may be baked out at 450°C for long periods (10 to 20 hours) to achieve complete degassing.

**How it's done:** Except for the expansion bend that permits expansion without rupture during bakeout, the gauge portion of the system is conventional. Below the expansion bend, the gauge tubing passes through a hole in the oven base into a stainless steel mercury

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cutoff valve. A flexible stainless steel tube connects the mercury cutoff valve to the stainless steel mercury reservoir that can be raised and lowered by means of a threaded block and lead screw arrangement. Atop the reservoir there is a closed-end manometer that continuously indicates the level of vacuum in the reservoir. A stainless steel valve above the manometer permits addition or removal of mercury and also permits purging of any gas in the reservoir.

As the mercury reservoir is raised by action of the threaded block and lead screw, mercury enters the compression bulb and compresses a portion of the gas, whose pressure is to be measured, into the capillary tube above the compression bulb. Obeying Boyle's law, the compressed gas exerts sufficient pressure to support a column of mercury in the calibrated tube sufficient for a reading. Readings are essentially independent of the composition of the gas.

Following the reading, the reservoir with its purge valve open is lowered until all mercury has drained to a point below the mercury cutoff valve, the valve is closed and the oven is fired for gauge bakeout in preparation for its next use.

**Note:** This system makes an excellent tool for the calibration of instruments designed for use in ultrahigh vacuum ranges and which are more convenient to use for frequent measurements.

**Patent status:** Title to this invention has been waived under the provisions of the National Aeronautics and Space Act (42 U.S.C. 2457 (f)), to the GCA Corporation, Bedford, Massachusetts.

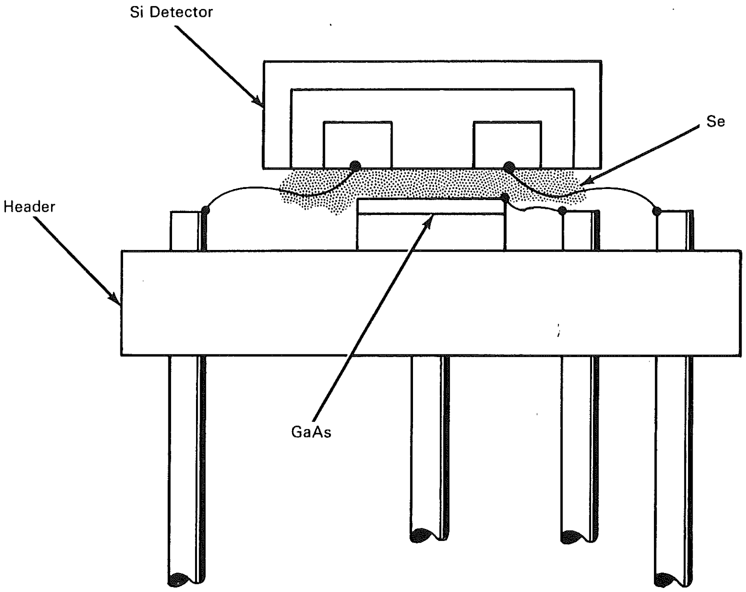
Source: Wallace S. Kreisman of GCA
Corporation under contract to
Goddard Space Flight Center
(GSFC-440)

November 1965

Brief 65-10324

# NASA TECH BRIEF

## Selenium Bond Decreases *On* Resistance of Light-Activated Switch



**The problem:** To decrease the *on* resistance of a gallium arsenide–silicon (GaAs–Si) light-activated, low-level switch by reducing the light diffusion through the bonding agent between the Si detector (photosensitive element) and the GaAs diode actuator.

**The solution:** Use vitrified amorphous selenium (whose refractive index is close to that of the actuator) as a bonding agent instead of an epoxy resin.

**How it's done:** A GaAs diode is mounted on a header, and a small amount of powdered amorphous selenium is placed on the diode. The header is then heated to approximately 200°C and quickly cooled, thus forming a vitrified (glassy) selenium dome on the diode. The silicon detector is positioned on the selenium dome, the lead wires are connected to the header posts, and the header is reheated to 200°C. The detector is pressed into the fused selenium and the assembly is allowed to cool, thus forming an integrated light switch.

**Notes:**

1. The *on* resistance of the switch using selenium as the bonding agent is 50 ohms at an element separation distance (GaAs to Si) of 10 mils, compared to 150 ohms at a separation distance of 2 to 3 mils using an epoxy bonding agent.
2. This light-activated switch should be used under a pulse condition (low duty cycle) to prolong switch life and minimize errors due to heating, devitrification, and overdrawing.

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3. Inquiries concerning this innovation may be directed to:

Technology Utilization Officer
Jet Propulsion Laboratory
4800 Oak Grove Drive
Pasadena, California, 91103
Reference: B65-10324

**Patent status:** NASA encourages commercial use of this innovation. No patent action is contemplated by NASA.

Source: International Business Machines
under contract to
Jet Propulsion Laboratory
(JPL-SC-101)

November 1965 Brief 65-10333

# NASA TECH BRIEF

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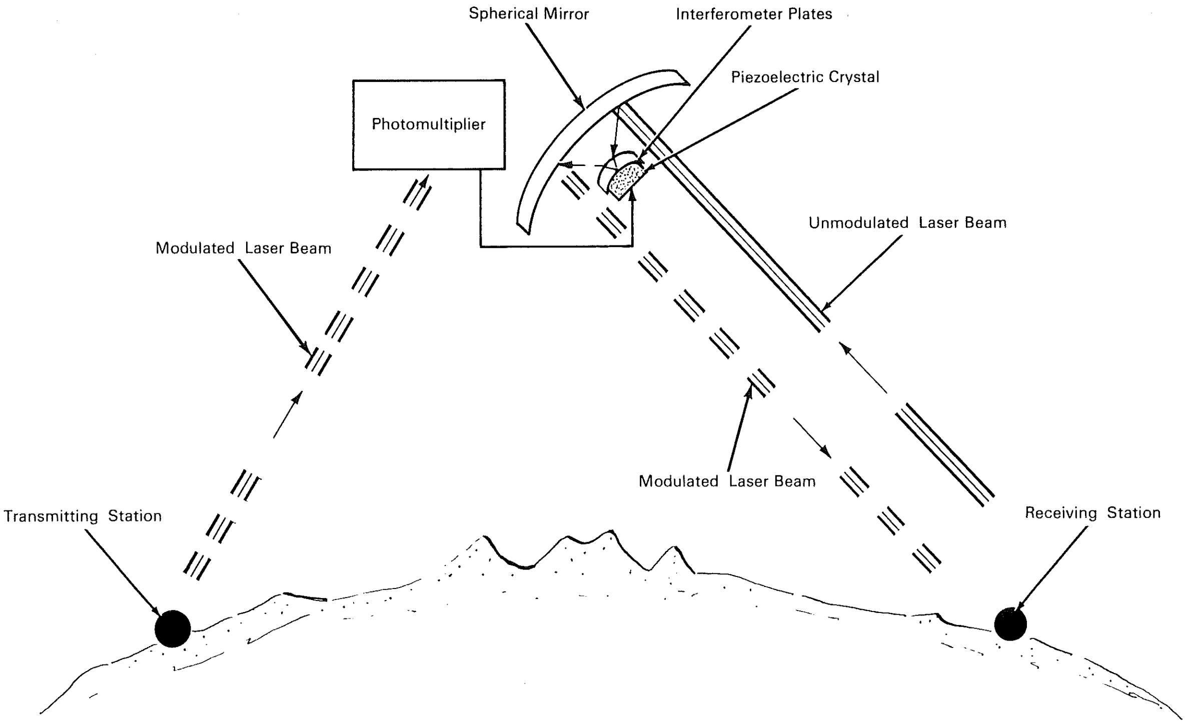
## Communication System Uses Modulated Laser Beam



**The problem:** To develop a laser-beam system for communicating between two remote stations via satellite.

**The solution:** An electro-optical system employing an essentially passive, retrodirective, laser beam modulator–reflector aboard the satellite.

**How it's done:** The modulator–reflector consists of a catadioptric lens (combining a spherical mirror and a refractor which corrects for mirror aberration), closely spaced curved interferometer plates mounted in the focal surface of the lens, and a piezoelectric crystal. The spacing between the interferometer plates is made to vary by applying a signal voltage to the piezoelectric crystal. When an unmodulated laser beam parallel to the optical axis of the lens system strikes the surface of the spherical mirror, the beam is reflected to the focal surface where it is modulated by the optical interference patterns generated between the interferometer plates. The modulated beam passes to the spherical mirror from which it is reflected in a direction parallel to, but opposite in sense to, that of the original unmodulated beam.

In operation, a modulated laser beam from a ground station is directed to a receiver on the

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satellite. This receiver, consisting of a photomultiplier, converts the laser signal to an electrical signal which is used to drive the piezoelectric crystal in the modulator–reflector at the modulation rate. An unmodulated laser beam from another ground station (the receiving station) is directed to the modulator reflector aboard the satellite where it acquires the modulation (information signal) being transferred by the information-carrying beam to the piezoelectric crystal and interferometer plates. The modulated laser beam from these plates is retrodirected by multiple reflection in the optical system to the receiving station.

**Notes:**

1. The spacing between the interferometer plates can be varied by other means instead of using an electrically driven piezoelectric crystal.
2. A parabolic mirror could be used, instead of a spherical mirror, to focus the beam on the interferometer.
3. The laser beam retrodirective modulator–reflector could have application in a line-of-sight communication system in situations where weight or power limitations are critical.
4. Inquiries concerning this invention may be directed to:

   Technology Utilization Officer
   Goddard Space Flight Center
   Greenbelt, Maryland, 20771
   Reference: B65-10333

**Patent status:** NASA encourages the immediate commercial use of this invention. Inquiries about obtaining rights for its commercial use may be made to NASA, Code AGP, Washington, D.C., 20546.

Source: Peter O. Minott
(GSFC-377)

November 1965 Brief 65-10334

# NASA TECH BRIEF

## Frequency Divider Is Free of Spurious Outputs

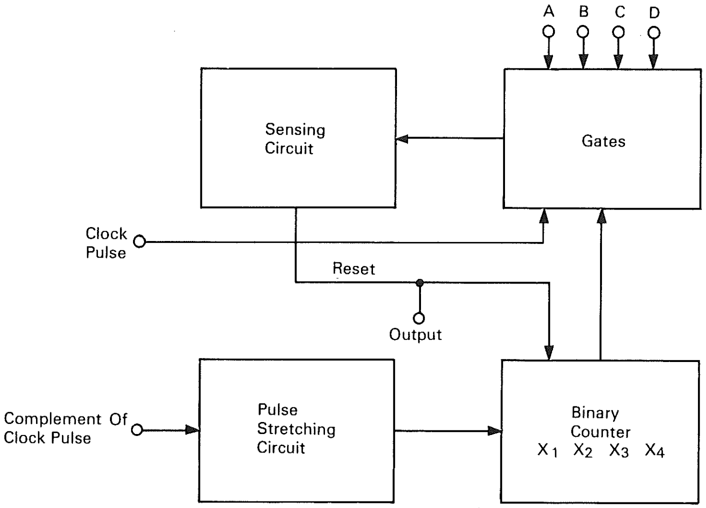

FIGURE 1

| Input<br>D C B A | No. Of States | Output<br>$X_1 X_2 X_3 X_4$ |
|---|---|---|
| 1 1 1 1 | 1 | 0 0 0 0 |
| 1 1 1 0 | 2 | 0 0 0 1 |
| 1 1 0 1 | 3 | 0 0 1 0 |
| 1 1 0 0 | 4 | 0 0 1 1 |
| 1 0 1 1 | 5 | 0 1 0 0 |
| 1 0 1 0 | 6 | 0 1 0 1 |
| 1 0 0 1 | 7 | 0 1 1 0 |
| 1 0 0 0 | 8 | 0 1 1 1 |
| 0 1 1 1 | 9 | 1 0 0 0 |
| 0 1 1 0 | 10 | 1 0 0 1 |
| 0 1 0 1 | 11 | 1 0 1 0 |
| 0 1 0 0 | 12 | 1 0 1 1 |
| 0 0 1 1 | 13 | 1 1 0 0 |
| 0 0 1 0 | 14 | 1 1 0 1 |
| 0 0 0 1 | 15 | 1 1 1 0 |
| 0 0 0 0 | 16 | 1 1 1 1 |

FIGURE 2

**The problem:** To design a compact, stable frequency divider that will provide 16 output states from only 4 input circuits. The output must be free of spurious pulses related to triggering and resetting of the binaries.

**The solution:** A system of integrated circuits that count the number of input pulses and provide a positive-going output pulse for a selected number of inputs.

**How it's done:** The divider consists of 4 main circuits: a pulse stretching circuit, a counter, a set of gates, and a sensing circuit. The pulse stretching circuit makes the negative going transient of the complement of clock pulse occur at a later time than the positive going transient of the clock pulse. Thus the counter is reset to zero before the completion of a given number of states, determined by the amount of stretching of the complement of clock pulse. This prevents spurious pulses that might occur at the output of the binaries due to trying to trigger the binaries to the next state and reset them to zero at the same time. The counter functions as any binary counter and the gates combine any selected combination of binary outputs with the clock pulse to trigger the sensing circuit, which is essentially a one-shot monostable multivibrator. The sensing circuit delays application of the reset pulse until the negative going transient from the gate occurs and also extends the duration of the reset pulse a sufficient time to insure that all binaries are reset to zero. Figure 2 illustrates the mode of system operation. If the input is made 1111, $X_1$, $X_2$, $X_3$, and $X_4$ all remain at zero. If an input corresponding to a larger number of output states is selected, the output states will occur in order as illustrated. For example, if the input corresponding to 10 states is selected and the device set to zero, the output will proceed to 1001, reset to 0000 and then count to 1001 again. This will be repeated until the input is changed.

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**Notes:**

1. Only 4 inputs are required for a 16-state system instead of 7 as in previous devices.
2. The input is binary coded. When the unit is set to zero and allowed to count to a given output state, the output states also occur in ascending order in a binary code.
3. For any change of one in the input, the number of output states is only changed by one.
4. Inquiries concerning this invention may be directed to:

Technology Utilization Officer
Goddard Space Flight Center
Greenbelt, Maryland, 20771
Reference: B65-10334

**Patent status:** NASA encourages the immediate commercial use of this invention. Inquiries about obtaining rights for its commercial use may be made to NASA, Code AGP, Washington, D.C., 20546.

Source: Duane McDermond
(GSFC-308)

November 1965 Brief 65-10340

# NASA TECH BRIEF

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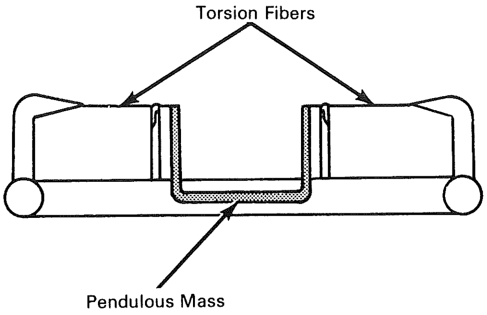
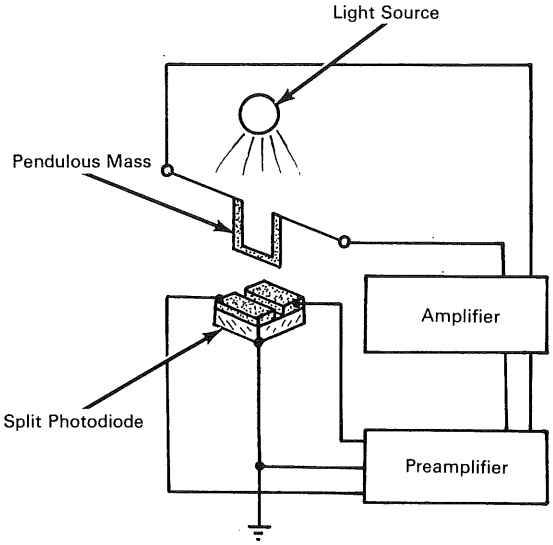
## Miniature Servo Accelerometer Is Force-Balanced





**The problem:** To design an accelerometer that is small, rugged, and simple in construction and that incorporates sensitivity and accuracy comparable to the output of more bulky, complicated, and sophisticated instruments.

**The solution:** A miniature servo accelerometer whose pendulous mass is suspended by fused quartz torsion fibers in an electromagnetically force-balanced environment.

**How it's done:** The "U" shaped pendulous mass is suspended by fused quartz fibers connected to each arm of the U. The fibers restrict all movement of the pendulous mass (except a torsional response to an applied acceleration). The pendulous mass, with its suspension system, is coated with a thin layer of gold to make it electrically conductive. Two permanent magnets are placed (with like poles facing) on either side of the pendulous mass, setting up a uniform magnetic field around the pendulous mass in its normal center position as suspended by the torsion fibers. A light source is mounted above the pendulous mass and a split photosensitive diode is mounted beneath the mass and between two shutters that direct the light to both sensitive faces of the split diode about the pendulous mass. With the instrument at rest, an equal amount of light falls on each face of the diode and their output currents cancel. When an accelerative force causes the pendulous mass to move from its center position along its sensitive axis, more light falls on one face of the photodiode than on the other. As a result, feedback current is applied to the electrically conductive pendulous mass in the appropriate polarity, thus producing a restoring force on the mass and bringing it back to its center position.

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**Notes:**

1. This would be useful in gravity surveys for exploring mineral deposits, particularly oil.
2. The invention could be used as a surface attitude servo device to register surface changes in attitude with respect to the vertical, and to feed an output to a corrective electromechanism.
3. The technique lends itself particularly to measurement of unusually small forces or torques.

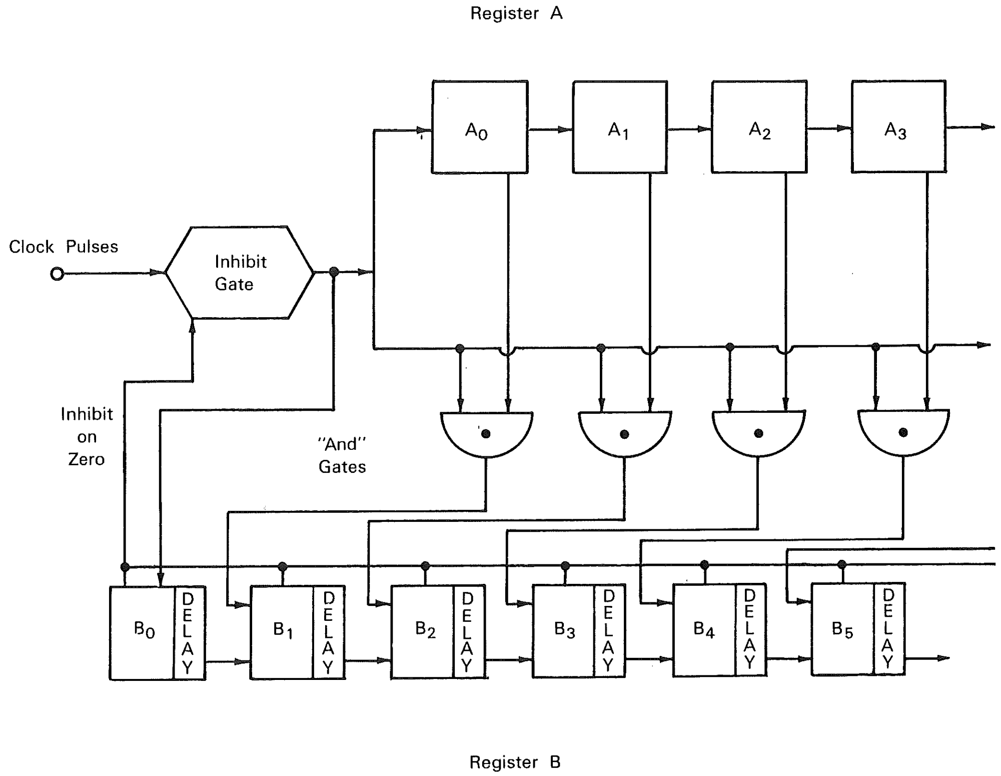
**Patent status:** Title to this invention (covered by U.S. Patent No. 3,091,972) has been waived under the provisions of the National Aeronautics and Space Act (42 U.S.C. 2457(f)) to the California Institute Research Foundation, Pasadena, California.

Source: Alan R. Johnston of
California Institute Research Foundation
under contract to
Jet Propulsion Laboratory
(JPL-155)

November 1965 Brief 65-10343

# NASA TECH BRIEF

## Delayed Ripple Counter Simplifies Square-Root Computation



**The Problem:** Simplifying the logic circuitry required in a binary computing device to derive the square root of a number. Prior circuitry has used analog methods, combinational logic matrices, or Newton approximation methods. The equipment required was not only complex, but required appreciable power.

**The solution:** Successively higher numbers are subtracted from a register containing the number out of which the square root is to be extracted. Using the ripple subtract technique, the last number subtracted will be the closest integer to the square root of the number.

**How it's done:** Register A is an ordinary counter. If it is started at zero, after n clock pulses it will contain the number n. Register B is also a binary counter, but it subtracts rather than adds when it is pulsed. A pulse fed to its first stage subtracts 1 from

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its contents, a pulse fed to its second stage subtracts 2 from its contents, a pulse to its third stage subtracts 4 from its contents, and so on. Output of the first stage of register A is fed to the second stage of register B, output of the second stage of register A to the third stage of register B, etc.

The contents of register A are initially set to zero and the contents of register B, the ripple subtract counter, are set to M. The clock pulses sequentially advance register A and at the same time subtract the contents of each stage of register A containing a "1" from the next stage of register B. When the contents of register B reach zero or a negative value, the clock pulses are inhibited and the value of the closest integer to the square root of M is read from register A.

**Notes:**

1. This circuit could be combined with a small computing device (such as a desk-top calculator that uses ripple adding counters) to provide square-root capabilities.
2. This circuit could be used to speed root mean square computations and to perform coordinate transformations.
3. Inquiries concerning this invention may be directed to:

Technology Utilization Officer
Goddard Space Flight Center
Greenbelt, Maryland, 20771
Reference: B65-10343

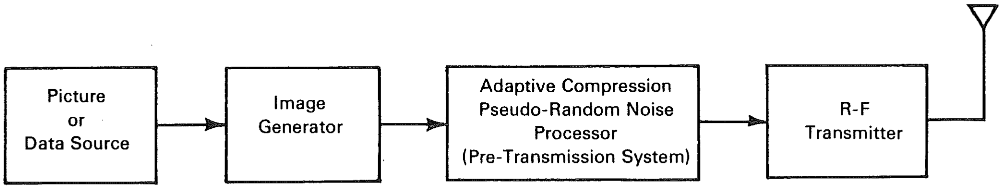
**Patent status:** NASA encourages the immediate commercial use of this invention. Inquiries about obtaining rights for its commercial use may be made to NASA, Code AGP, Washington, D.C., 20546.

Source: Rodger Cliff
(GSFC-398)

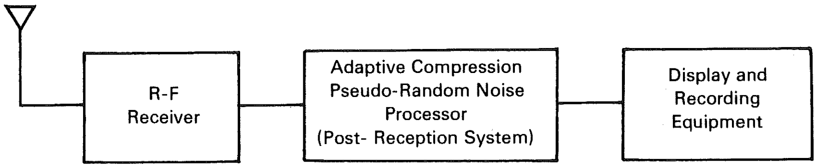
November 1965 Brief 65-10345

# NASA TECH BRIEF

## Variable Word Length Encoder Reduces TV Bandwidth Requirements


Picture or Data Source
Image Generator
Adaptive Compression Pseudo-Random Noise Processor (Pre-Transmission System)
R-F Transmitter

TRANSMITTING SYSTEM


R-F Receiver
Adaptive Compression Pseudo-Random Noise Processor (Post- Reception System)
Display and Recording Equipment

RECEIVER SYSTEM

**The problem:** To obtain more efficient transmission of pulse code modulated television signals by reducing the required bandwidth. An earlier method added pseudo-random noise to the television signal prior to encoding and transmission and removed the noise from the composite signal after it was received. Bandwidth compression was achieved but the bandwidth compression was limited to positive integers and to one fixed value of compression, set prior to use, and thereafter unalterable. It is also desirable to obtain positive mixed number compression ratios as well as postive integer compression ratios.

**The solution:** Utilize an adaptive variable resolution (variable word length) encoding technique to provide an adaptive compression pseudo-random noise signal processor. The processor is used to reduce the channel capacity required for signal transmission. Complementary processors are required in both the transmitting and receiving systems. The pretransmission processor is analog-to-digital in nature, while the postreception processor is digital-to-analog.

**How it's done:** The pretransmission processor (PTP) is placed between the image generator and the

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transmitter in the transmission system. The postreception processor (PRP) is placed between the receiver and the display and recording equipment.

The basic function of the PTP is to add an adapted pseudo-random noise to the picture data and encode this combined signal by means of a variable resolution encoder. This process generates a pulse-coded picture-plus-noise signal which modulates a transmitter that satisfies the communication system transmission requirements. The PTP obtains analog-to-digital conversion by means of a variable resolution analog-to-digital converter which is capable of converting input voltage into a 1 through n bit word. The number of bits per word is selected by a variable compression control generator.

After the signal has been received and decoded, the PRP puts the signal through a variable resolution digital-to-analog converter which decodes it into an analog signal. The adapted pseudo-random noise from the combined analog signal is then removed and processed by a compensator to give an output equivalent to the input signal the PTP was given.

**Notes:**

1. The following capabilities make this technique superior to prior art:
   a. Switching to a number of encoder resolutions, between encoder samples, provides positive mixed number compression ratios in pseudo-random noise picture compression systems.
   b. Adapting the decoded level of pseudo-random noise added to a picture signal in a compression system so that its full-scale value will follow, in real time, the equivalent weight of the least significant bit of the picture signal encoder.
   c. Output buffering of a number of inputs, differing in bit rate as a function of sampling and encoding conditions, in a manner rendering an output bit rate equal to the average bit rate of the inputs, over a conditional sampling cycle. (A sampling cycle is defined as a series of samples including a total number of samples as required to include one encoded sample of each different word length employed in the compression systems.)
   d. Altering the compression capability of a pseudo-random noise picture compression system, manually (preset or remotely controlled) or automatically (programmed or diagnostic processing) to satisfy real time operational conditions.
2. Inquiries concerning this invention may be directed to:

Technology Utilization Officer
Langley Research Center
Langley Station
Hampton, Virginia, 23365
Reference: B65-10345

**Patent status:** NASA encourages the immediate commercial use of this invention. Inquiries about obtaining rights for its commercial use may be made to NASA, Code AGP, Washington, D.C., 20546.

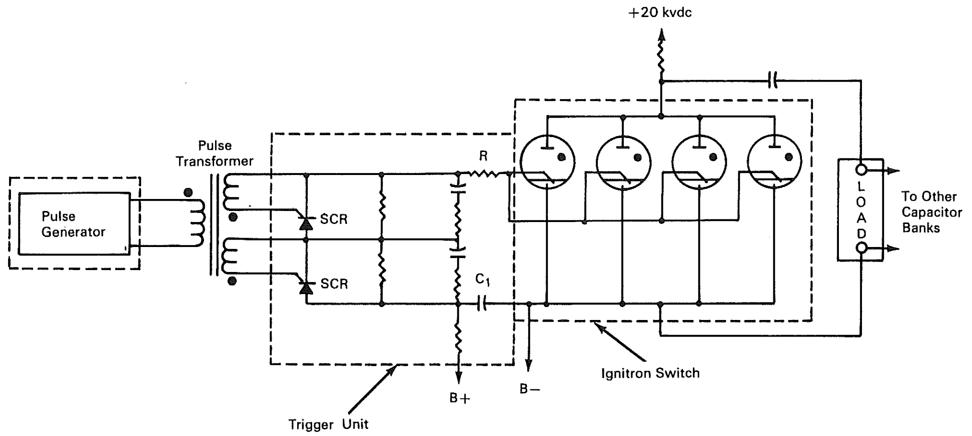
Source: Wilford E. Sivertson, Jr.
(Langley-87)

November 1965 Brief 65-10347

# NASA TECH BRIEF

NASA Tech Briefs are issued by the Technology Utilization Division to summarize specific technical innovations derived from the space program. Copies are available to the public from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia, 22151.

## Compact SCR Trigger Circuit for Ignitron Switch Operates Efficiently



**The problem:** To design a compact, efficient circuit that will trigger an ignitron switch (consisting of four parallel-connected ignitrons) used to discharge high-energy (low-inductance) capacitor banks. The input pulse generator must be electrically isolated from the high-voltage circuitry in order to prevent arc-over between charged and uncharged capacitor banks and to protect operating personnel.

**The solution:** A trigger circuit utilizing two series-connected SCR's (silicon controlled rectifiers).

**How it's done:** An isolating pulse transformer couples the pulse generator to the input of the trigger circuit. The high peak current rating and voltage holdoff capability of the SCR's eliminates the need for a load matching transformer. It is necessary, however, to connect a current-limiting resistor (R) in series with the SCR's and the ignitor element of each ignitron to prevent damage to the SCR's. The SCR'S trigger the four ignitrons by discharging trigger capacitor $C_1$ directly through the discharge path comprised of the ignitor-to-cathode resistances in series with the limiting resistor R.

**Notes:**

1. The pulse transformer can be physically small because of its relatively low power requirements at the trigger circuit input. It can also be directly coupled to the pulse generator at a remote location to provide maximum protection from the high-voltage lines.
2. Since the SCR's are solid-state devices, the trigger circuit does not require a warmup period and operates at relatively high efficiency.
3. Matching of the ignitor-to-cathode resistances may be critical.

(continued overleaf)

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4. Inquiries concerning this invention may be directed to:

Technology Utilization Officer
Marshall Space Flight Center
Huntsville, Alabama, 35812
Reference: B65-10347

**Patent status:** NASA encourages the immediate commercial use of this invention. Inquiries about obtaining rights for its commercial use may be made to NASA, Code AGP, Washington, D.C., 20546.

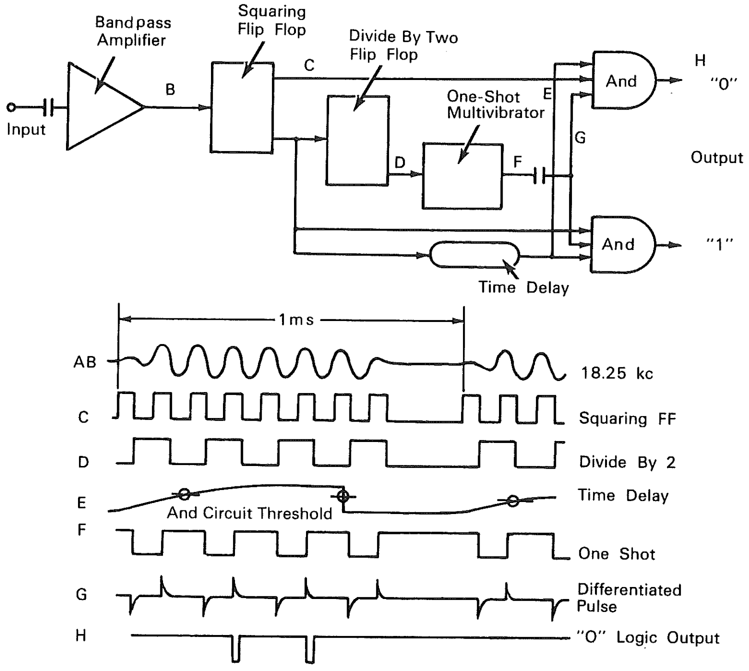
Source: L. E. Foster
(M-FS-371)

November 1965 Brief 65-10349

# NASA TECH BRIEF

NASA Tech Briefs are issued by the Technology Utilization Division to summarize specific technical innovations derived from the space program. Copies are available to the public from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia, 22151.

## Frequency Discriminator with Binary Output Eliminates Tuned Circuits


Bandpass Amplifier
Squaring Flip Flop
Divide By Two Flip Flop
Input
B
C
D
E
F
G
H
One-Shot Multivibrator
And
And
"0"
Output
"1"
Time Delay
1 ms
AB
18.25 kc
Squaring FF
Divide By 2
And Circuit Threshold
Time Delay
One Shot
Differentiated Pulse
"0" Logic Output

**The problem:** To design a frequency discriminator with a binary output using components that permit the use of microminiaturized packaging techniques. Present output producing devices employ tuned circuits that are too bulky for microminiature packaging.

**The solution:** A bandpass amplifier and standard logic elements that convert two input frequencies into two discrete logic pulses. Output is restricted to a defined time increment to eliminate the possibility of circuit response to either noise or transients.

**How it's done:** The input frequency spectrum is fed to the bandpass amplifier that combines negative feedback with a parallel T-network rather than tuned circuits. Amplifier output, which will be either of two selected frequencies, is fed to a squaring flip-flop that converts the sinusoidal input to a square waveform. The complementary outputs from the squaring flip-flop are sent to both *AND* elements. The self-terminating time delay is actuated by the squaring flip-flop output and controls *AND* element output by establishing an operating threshold level. Output from a divide by two flip-flop is at one half the input signal frequency and actuates a one-shot multivibrator whose output is differentiated and serves as the third input to the *AND* elements.

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The time delay serves to inhibit logic outputs until all transients resulting from input signal start have subsided and also uses its self-terminating characteristic to suppress transients that might be generated at signal fadeout. The one-shot multivibrator is triggered in coincidence with the squaring flip-flop output, but generates an output whose time duration is independent of the input frequency to be discriminated. The duration of this waveform, and the relative position of the resultant differentiated output pulse, is selected to occur simultaneously at one of the *AND* elements with change of state of the squaring flip-flop. This timing is such that one selected input frequency will cause the required coincidence to occur at one *AND* element and the other selected input frequency will cause coincidence at the second *AND* element. The figure illustrates the waveforms resulting in a zero logic output at waveform H from an input frequency A. A system input of frequency B would, in a similar manner, result in a one logic output at the other *AND* element.

**Notes:**

1. This circuit has been satisfactorily operated over a temperature range from −55° to +100°C.
2. This invention was developed as a frequency-shift keying demodulator in a satellite instrument unit command decoder.
3. Inquiries concerning this invention may be directed to:

   Technology Utilization Officer
   Marshall Space Flight Center
   Huntsville, Alabama, 35812
   Reference: B65-10349

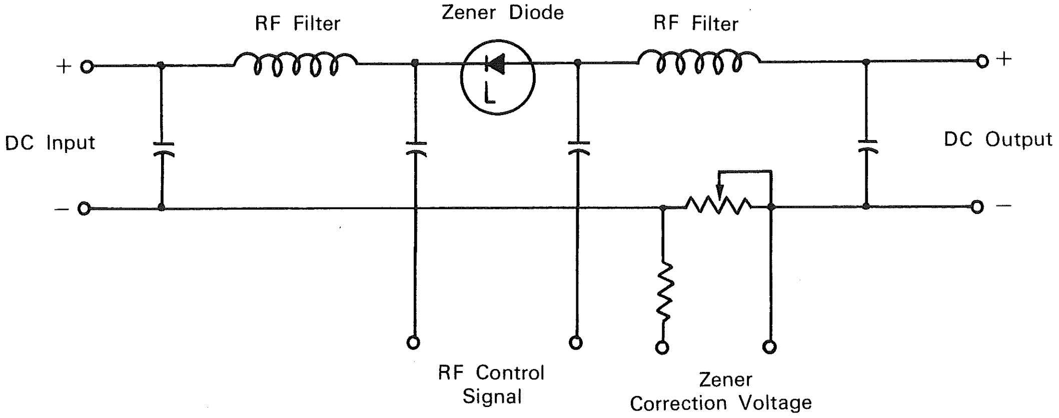
**Patent status:** NASA encourages the immediate commercial use of this invention. Inquiries about obtaining rights for its commercial use may be made to NASA, Code AGP, Washington, D.C., 20546.

Source: E. DeVelde of IBM Corporation
under contract to
Marshall Space Flight Center
(M-FS-376)

November 1965 Brief 65-10350

# NASA TECH BRIEF

## Zener Diode Controls Switching of Large Direct Currents



**The problem:** To design a simple circuit to control the switching (gating) of large dc signals.

**The solution:** A high-current zener diode is connected in series with the positive input terminal of the dc supply to block the flow of direct current until a high-frequency (RF) control signal is applied across the zener diode.

**How it's done:** The zener diode, being a high-impedance device, prevents the flow of direct current, as long as the zener voltage is not exceeded. When the RF control signal is applied to the dc blocking capacitors across the zener diode, its impedance drops to a very low value and therefore permits essentially full direct-current flow from the dc input to output terminals.

The RF filters and blocking capacitors isolate the dc lines from the RF lines. The zener correction-voltage input compensates for the small dc voltage drop across the diode during the conduction state.

**Note:** Inquiries concerning this innovation may be directed to:

Technology Utilization Officer
Manned Spacecraft Center
P.O. Box 1537
Houston, Texas, 77001
Reference: B65-10350

**Patent status:** NASA encourages commercial use of this innovation. No patent action is contemplated by NASA.

Source: IBM Space Guidance Center under contract to Manned Spacecraft Center
(MSC-188)
Category 01

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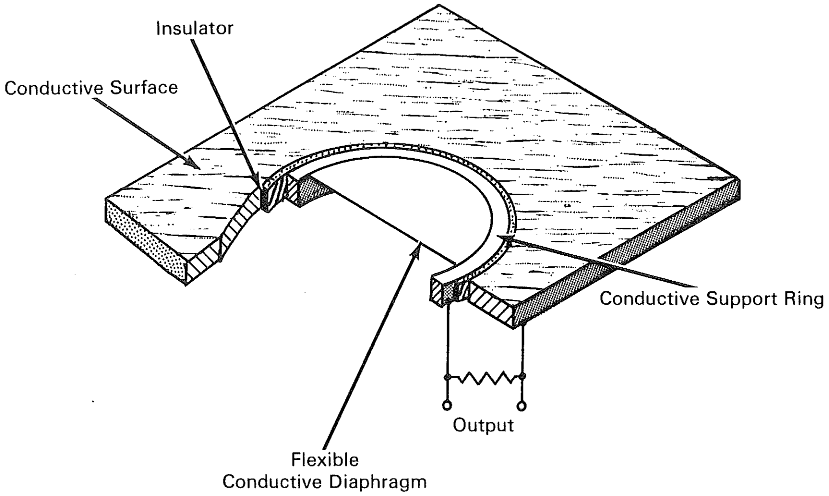
November 1965 Brief 65-10352

# NASA TECH BRIEF

## Vibrating Diaphragm Measures High Electrostatic Field Strengths



**The problem:** To provide an improved device for the measurement of electrostatic field strength or charge density on a conducting surface in a vacuum. Devices employing a rotating plate (the electric field mill) or a vibrating disk for the electrical measurements present problems with respect to brush design, vacuum sealing, lubrication of moving parts, and the reliability of flexibile conducting wires. These devices also cannot be used for measurement of high charge densities in vacuum because of field emission or corona from the edges of the plates or disks.

**The solution:** A meter incorporating a flexible conductive diaphragm that is supported from an insulated conductive support ring rigidly attached to the conductive surface whose electrostatic charge density is to be measured.

**How it's done:** A fixed resistor is connected between the conductive support ring and the conductive surface. In its equilibrium position, the diaphragm is flush with the conductive surface. When the diaphragm is vibrated about its equilibrium position by a suitable means (not illustrated), the charge density on its surface will vary at a rate determined by the vibration frequency. As a result of this variation, an alternating current proportional to the electrostatic field strength (or charge density) will flow in the resistor. The voltage across this resistor may be used as the output signal.

**Notes:**

1. This simple, stable, and rugged meter can be used in pressurized as well as in vacuum environments. It would be particularly useful for measuring high field strengths on a conductive surface in vacuum because corona and field emission are minimized.
2. The diaphragm can be driven (with relatively little power) at high frequencies to provide increased sensitivity.

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3. Inquiries concerning this invention may be directed to:

    Technology Utilization Officer
    Manned Spacecraft Center
    P.O. Box 1537
    Houston, Texas, 77001
    Reference: B65-10352

**Patent status**: NASA encourages the immediate commercial use of this invention. Inquiries about obtaining rights for its commercial use may be made to NASA, Code AGP, Washington, D.C., 20546.

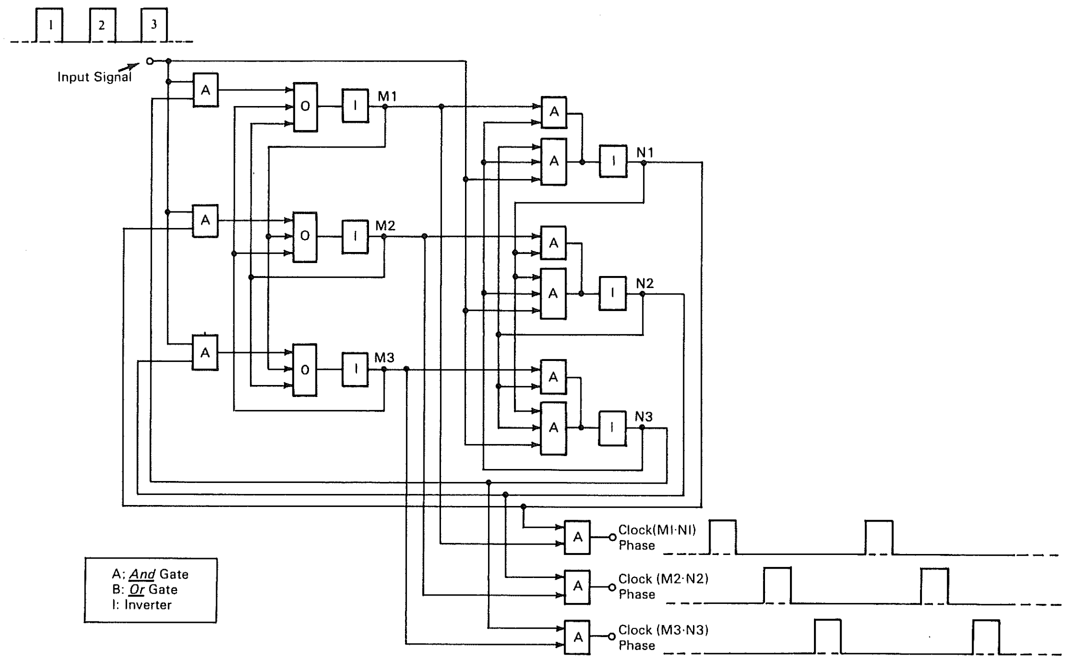
Source: Electro-Optical Systems, Inc.
under contract to Manned Spacecraft
Center
(MSC-189)

November 1965

Brief 65-10353

# NASA TECH BRIEF

## Multiphase Clock-Pulse Generator Uses Simplified Circuitry



THREE-PHASE CLOCK GENERATOR

**The problem:** To simplify multiphase clock-pulse generators required in most electronic pulse and digital logic systems. These clock-pulse generators have used relatively complex circuitry to avoid logical situations in which extraneous pulses might be formed.

**The solution:** A multiphase clock-pulse generator that converts a simple pulse train into nonoverlapping clock pulses. The generator employs multistable circuits, incorporating *and* gates, *or* gates, and inverters, to minimize the number of electronic components.

**How it's done:** The block diagram presents a three-phase clock-pulse generator to illustrate the operating principle of the multiphase system. The three-phase generator employs two tristable circuits interconnected to three output *and* gates which provide the clock pulses.

Each of the three stages of the first tristable circuit consists of an *and* gate, an *or* gate, and an inverter which are interconnected so that only one stage at a time can be at the up-level (1-state). For example, the respective outputs M1, M2, and M3 of this tristable circuit are initially in the 0, 0, 1 state. The second

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tristable circuit has outputs N1, N2, and N3. Each of the three stages of this circuit consists of two *and* gates coupled to an inverter, and only one stage at a time can be at the down-level (0-state).

The first tristable circuit changes state when the input signal is at an up-level. The second tristable circuit changes state when this signal is at a down-level. The state assumed by the first tristable circuit when the input is up-level depends on the state last stored in the second tristable circuit. The state assumed by the second tristable circuit when the input is down-level depends on the state last stored in the first tristable circuit. This interdependency between the tristable circuits is achieved by interconnections that allow the stages to advance through all states in an interleaved succession and then repeat. The three-phase clock signal is obtained by *and* gating M1 with N1, M2 with N2, and M3 with N3, respectively.

**Notes:**

1. The basic three-phase generator can be expanded to provide a multiphase (n-phase) clock output. In the n-phase generator, the first multistable circuit would have n stages and an initial condition of 0, 0, 0, . . . 0, 1. The second multistable circuit would also have n stages, but an initial condition of 1, 1, 1, . . . 1, 0. The nth-phase clock signal would be obtained by *and* gating Mn with Nn.
2. This type of generator should find application in pulse, digital, and pulse-coded electronic systems.
3. Inquiries concerning this invention may be directed to:

Technology Utilization Officer
Marshall Space Flight Center
Huntsville, Alabama, 35812
Reference: B65-10353

**Patent status:** NASA encourages the immediate commercial use of this invention. Inquiries about obtaining rights for its commercial use may be made to NASA, Code AGP, Washington, D.C., 20546.

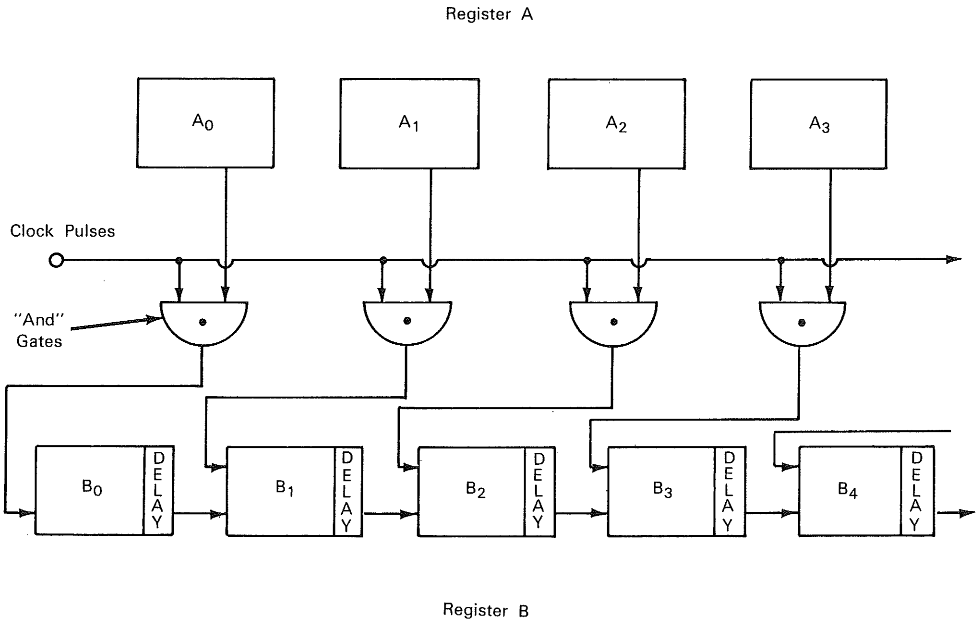
Source: IBM Federal Systems Division
under contract to
Marshall Space Flight Center
(M-FS-297)

Brief 65-10355

# NASA TECH BRIEF

NASA Tech Briefs are issued by the Technology Utilization Division to summarize specific technical innovations derived from the space program. Copies are available to the public from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia, 22151.

## Simple Circuit Performs Binary Addition and Subtraction



**The problem:** To reduce the number of logic circuits required to perform binary addition and subtraction. Previous methods have used separate units called adders or subtractors and have the disadvantages of excessive weight, circuit complexity, and high power drain.

**The solution:** A ripple adder that uses dual-input and delayed-output flip flops in one register. The contents of this register are summed with those of a standard register through conventional AND gates.

**How it's done:** The ripple adding circuit adds the contents of registers A and B and places the sum in register B. The flip flops that comprise register B have been modified by the addition of a second input trigger and an output pulse delay.

With a binary "1" stored in a stage of register A, the clock pulse passes through the AND gate corresponding to that stage and triggers the input of the corresponding stage of register B. For addition, register B is designed to give an output pulse on the "1"-to-"0" transition. This output pulse is delayed from the input of the next stage to permit the contents of register A to be transferred before the ripple pulses travel through register B. For subtraction, register B is designed to produce an output pulse on the "0"-to-"1" transition, and the circuit subtracts the contents of register A from the contents of register B.

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**Notes:**

1. This circuitry may be of interest to manufacturers of small computing equipment such as desk-top calculators.
2. Inquiries concerning this invention may be directed to:

   Technology Utilization Officer
   Goddard Space Flight Center
   Greenbelt, Maryland, 20771
   Reference: B65-10355

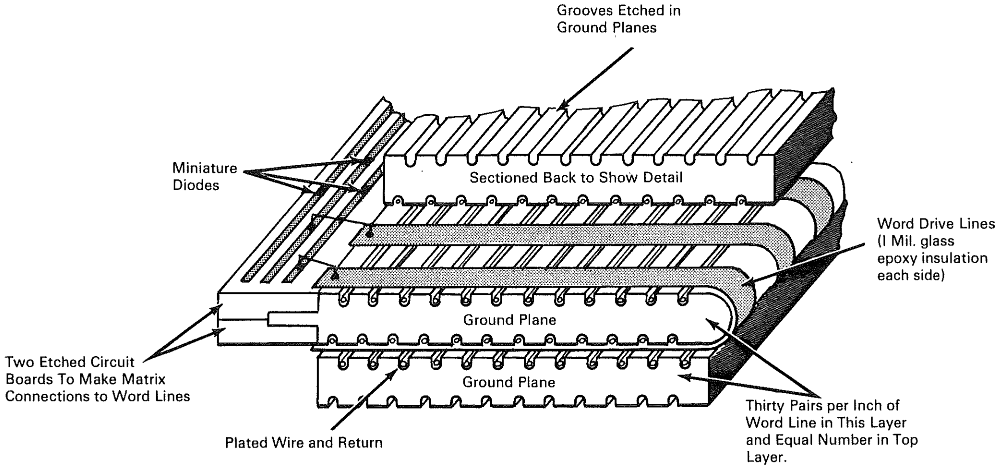
**Patent status:** NASA encourages the immediate commercial use of this invention. Inquiries about obtaining rights for its commercial use may be made to NASA, Code AGP, Washington, D.C., 20546.

Source: David H. Schaefer and
Rodger A. Cliff
(GSFC-399)

November 1965 Brief 65-10359

# NASA TECH BRIEF

## Improved Wire Memory Matrix Uses Very Little Power


Grooves Etched in Ground Planes
Miniature Diodes
Sectioned Back to Show Detail
Word Drive Lines (1 Mil. glass epoxy insulation each side)
Ground Plane
Two Etched Circuit Boards To Make Matrix Connections to Word Lines
Ground Plane
Thirty Pairs per Inch of Word Line in This Layer and Equal Number in Top Layer.
Plated Wire and Return

**The problem:** To design a compact, rugged memory matrix for computer applications where available power is a limiting factor. Ferrite-core memories draw 10 to 15 watts of average power and, in certain applications, this is intolerable.

**The solution:** A thin-film, plated-wire memory matrix that requires little power yet has higher speed and greater storage capacity than ferrite-core memories of the same size.

**How it's done:** A conducting ground plane of copper, magnesium, or aluminum has grooves etched in it to receive insulated plated wires. The wires are placed in the grooves and are held by a coating of varnish or other suitable material. Etched word lines, each supported between two flexible one-mil glass epoxy dielectric sheets, are wrapped around the ground plane and connected to the matrix connections on etched circuit boards bonded to the ground plane. Two additional ground planes, with plated wires in etched grooves, are placed on top of and beneath the first ground plane to enable one word line to serve many more bit lines.

**Notes:**

1. Placing the plated wire in this coaxial cable type structure reduces its surge impedance.
2. This configuration quadruples the number of bits per inch of word line over previous devices of the same size.

**Patent status:** Title to this invention has been waived under the provisions of the National Aeronautics and Space Act (42 U.S.C. 2457 (f)), to UNIVAC Division of Sperry Rand Corporation, P.O. Box 500, Blue Bell, Pennsylvania.

Source: George A. Fedde of UNIVAC Division
of Sperry Rand Corporation under
contract to Jet Propulsion Laboratory
(JPL-SC-167)
Category 01

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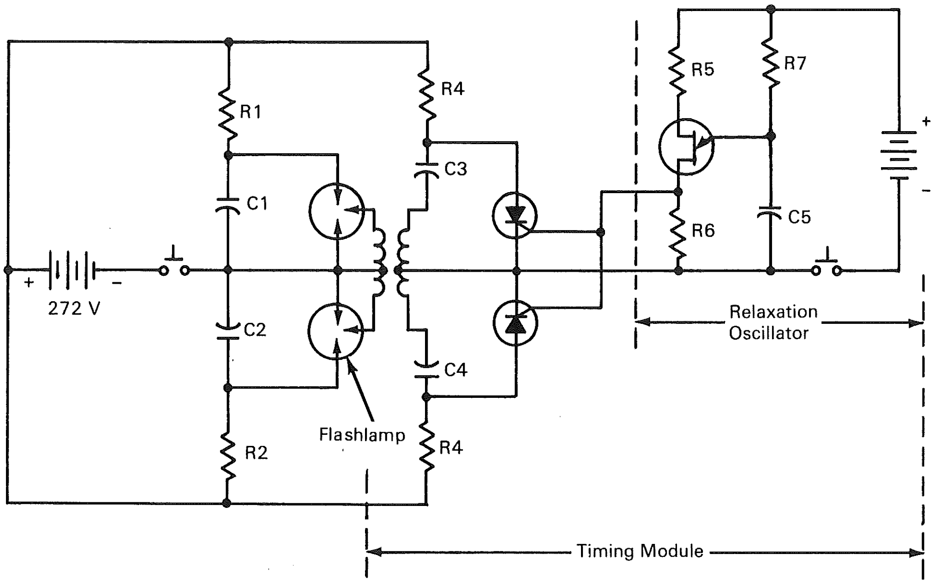
November 1965 Brief 65-10361

# NASA TECH BRIEF

## High-Intensity Flashing Beacon Powered by Mercury Cells



**The problem:** To design a lightweight, rugged, self-contained flashing beacon with an effective intensity of a second-magnitude star to a dark-adapted eye at a distance of 10 statute miles. The beacon must flash once each second for a minimum of five hours and must withstand shock and vibration.

**The solution:** A pair of xenon flashlamps powered by mercury batteries in a transistorized circuit. The entire set of components, with the exception of the flashlamps, is potted in silicone rubber and enclosed in a spherical aluminum shell. The weight of the assembly is approximately 10 pounds.

**How it's done:** The flash lamp circuit incorporates two power supplies and a timing module which includes a relaxation oscillator.

The lamp power supply consists of a battery of mercury cells connected in series to provide an open-circuit voltage of approximately 272 volts. This supply will deliver 185 milliamps of peak current each second for a minimum of 5 hours. The supply charges storage capacitors C1 and C2 (through resistors R1 and R2), and also capacitors C3 and C4 in the timing module.

One second after the switches are closed, the unijunction transistor in the relaxation oscillator turns on the silicon controlled rectifiers in the timing module. The capacitors C3 and C4 then discharge through the ignition transformers, causing an ionizing potential to be applied to the flashlamps. Each lamp emits approximately 100 lumen-seconds of light.

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The relaxation oscillator power supply also consists of a battery of mercury cells. The frequency of the relaxation oscillator is controlled by R7, C5, and the intrinsic standoff ratio of the unijunction transistor. R5 is a temperature compensation resistor for C5.

**Notes:**

1. The flashing beacon was designed for use in the NASA Flashing Satellite Program. The packaging configuration, weight, number of flashlamps, and flash frequency can be easily modified for application of the beacon as a maritime rescue marker or other luminous signal device.
2. Further information concerning this innovation is given in NASA TN D-2377, "Flashing-Beacon Experiment for Mercury-Atlas 9 (MA-9) Mission" by Charles C. Laney, Jr., available from Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia, 22151. Inquiries may also be directed to:

Technology Utilization Officer
Langley Research Center
Langley Station
Hampton, Virginia, 23365
Reference: B65-10361

**Patent status:** NASA encourages commercial use of this innovation. No patent action is comtemplated by NASA.

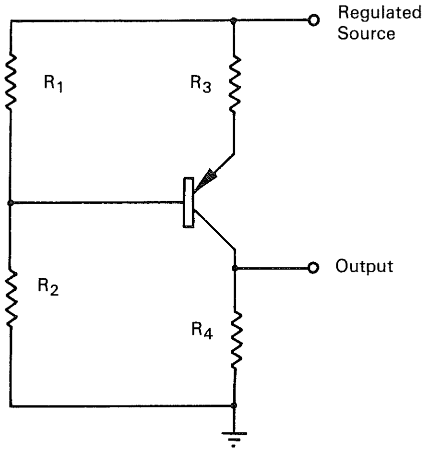
Source: (Langley-80)

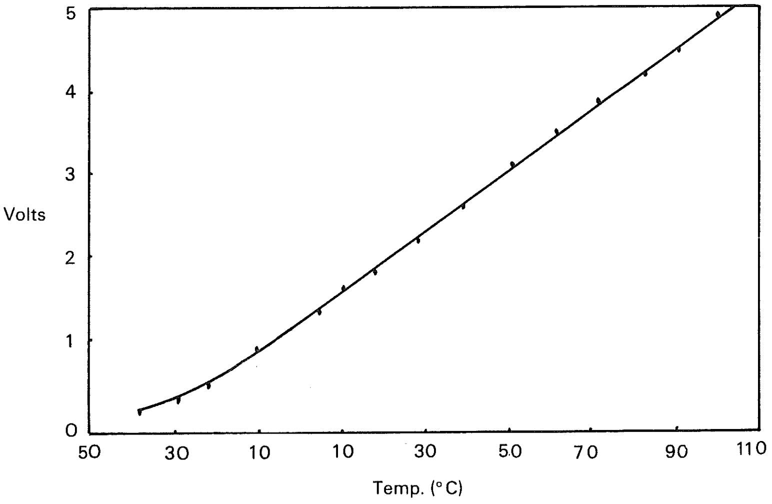
November 1965 Brief 65-10362

# NASA TECH BRIEF

NASA Tech Briefs are issued by the Technology Utilization Division to summarize specific technical innovations derived from the space program. Copies are available to the public from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia, 22151.

## Temperature Transducer Has High Output, Is Time Stable





**The problem:** To design a small, lightweight, temperature transducer with relatively linear output that requires no amplification of its output signal. Previous devices have used a semiconductor element in conjunction with a thermistor; but the thermistor is not time stable. The output signal, after required amplification, was not linearly proportional to the temperature being measured.

**The solution:** A compact, lightweight transducer that uses the temperature-dependent characteristics of a planar silicon transistor to provide a zero-to-five-volt signal proportional to temperature.

**How it's done:** The major element of the transducer is the transistor whose base is held at a constant voltage by a regulated source operating through a voltage divider $R_1$, $R_2$. The regulated source is also connected through the emitter resistor $R_3$. Output of the transducer is developed across the collector resistor $R_4$ to register the voltage change with temperature on an appropriate instrument. Principle of operation is the characteristic change of base-emitter voltage with changing temperature of a planar silicon transistor. The graph shows the relatively linear rise in output voltage with increase in temperature acting on the transducer.

**Notes:**

1. Transducer output is sufficient for telemetry purposes to the extent that no preamplification is required.
2. The transducer is disk-shaped and is approximately ½ inch in diameter by ⅓ inch thick. Weight, with 36-inch leads, is approximately 6 grams.

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3. Twelve of these transducers are presently providing temperature data on various experiments and components now flying aboard the Orbiting Solar Observatory (OSO-B2).

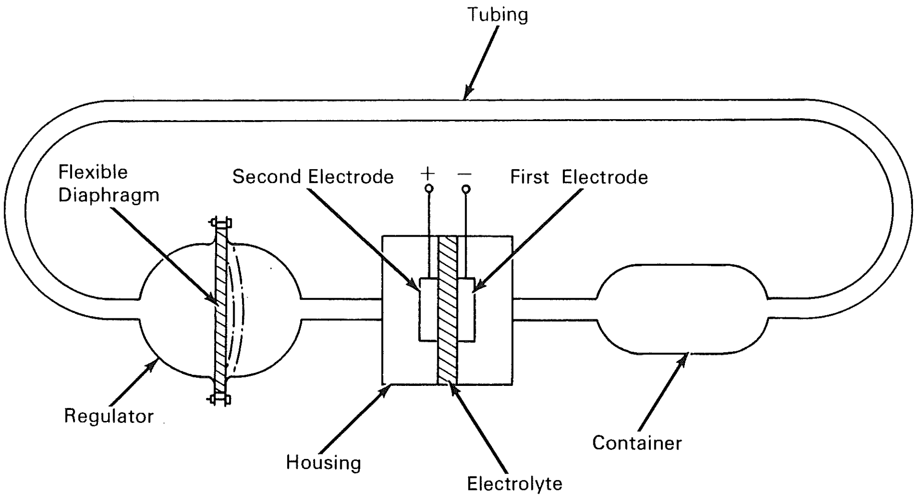
**Patent status:** Title to this invention has been waived under the provisions of the National Aeronautics and Space Act (42 U.S.C. 2457 (f)), to Ball Brothers Research Corporation, Boulder Industrial Park, Boulder, Colorado.

Source: William H. Follett of Ball Brothers
Research Corporation under contract
to Goddard Space Flight Center
(GFSC-446)

December 1965 Brief 65-10363

# NASA TECH BRIEF

## Regenerative Fuel Cell Combines High Efficiency with Low Cost



**The problem:** To provide an electrical energy storage medium that is lightweight, efficient, and inexpensive. Conventional storage batteries exhibit poor energy-to-weight ratios and are generally unreliable over a large number of cycles especially where deep discharge is a duty requirement. Prior-art fuel cells attain relatively poor efficiency, exhibit limited current density, and have limited useful life.

**The solution:** A hydrogen/oxygen regenerative fuel cell that features high efficiency and low cost and is adapted for a large number of cycles with deep discharge. The unit output achieves a high energy-to-weight ratio.

**How it's done:** The fuel cell consists of two gas-permeable electrodes contacting and separated by a body of electrolyte, all completely enclosed in a housing. The first electrode is of inert platinized nickel, the second electrode is of silver, and the electrolyte body is a fine, porous, nonconducting bed of asbestos that is partially saturated with an aqueous solution containing 35% potassium hydroxide by weight. When the cell is initially charged with a predetermined amount of electrical energy, electrolysis occurs in the electrolyte solution producing hydrogen gas from the first electrode and oxygen gas from the second electrode. The hydrogen gas is stored in a container connected to the first-electrode side of the housing and its pressure is controlled by a regulator connected to the other side of the housing and containing a flexible diaphragm through its center. Substantially all of the oxygen gas produced at the second electrode immediately combines with it to form silver oxide. Balancing of the gas pressures within the system is by action of the regulator diaphragm being expanded by the hydrogen gas so as to reduce the volume containing the oxygen gas.

When a predetermined amount of electrical energy is discharged from the cell, the silver oxide is reduced to pure silver and the gaseous hydrogen reacts with the

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hydroxyl ions formed at the silver electrode to produce water which is absorbed into the electrolyte bed. Thus the cell is regenerative, and, upon application of another charge, the gas-producing cycle will be repeated.

**Notes:**

1. This cell was charged at room temperature for a period of 2 hours with a current of 50 milliamps at 1.16 volts. It was then discharged at room temperature for 2 hours and delivered a current of 50 milliamps at 1.12 volts. Thus, voltage efficiency was about 96.5%, current efficiency about 95%, and power efficiency about 91.7%. Prior art normally failed to achieve 70% efficiency.
2. Energy-to-weight ratios in the vicinity of 70 watt-hours per pound have been achieved. Conventional wet batteries normally deliver from 5 to 15 watt-hours per pound.

**Patent status:** Title to this invention has been waived under the provisions of the National Aeronautics and Space Act (42 U.S.C. 2457 (f)), to Electro-Optical Systems, Inc., 300 North Halstead Street, Pasadena, California, 91107.

Source: Harlan Doyle, Harvey Frank, and
Charles W. Stephens of Electro-Optical
Systems, Inc. under contract to
Western Operations Office
(WOO-090)

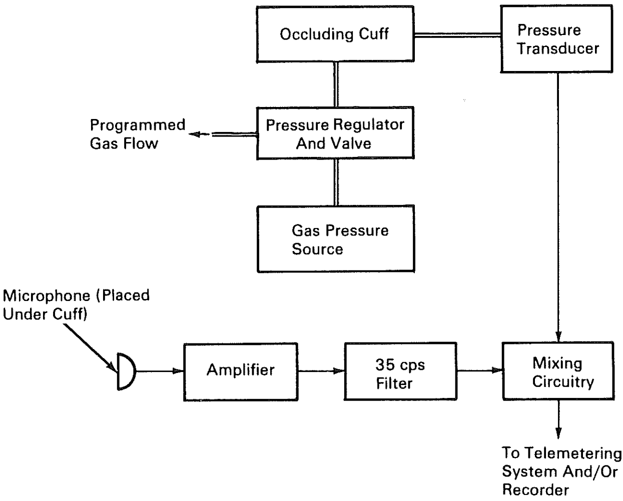
December 1965

Brief 65-10365

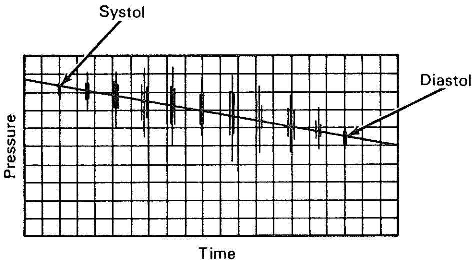
# NASA TECH BRIEF

NASA Tech Briefs are issued by the Technology Utilization Division to summarize specific technical innovations derived from the space program. Copies are available to the public from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia, 22151.

## Blood-Pressure Measuring System Gives Accurate Graphic Output



SYSTEM SCHEMATIC



TYPICAL OUTPUT TRACE

**The problem:** To develop an instrument that will provide an external (indirect) measurement of arterial blood pressure in the form of an easily interpreted graphic trace that can be correlated with standard clinical blood-pressure measurements. From sphygmograms produced by conventional sphygmographs, it is very difficult to differentiate the systolic and diastolic blood-pressure pulses and to correlate these indices with the standard clinical values. It is nearly impossible to determine these indices when the subject is under physical or emotional stress.

**The solution:** An electronic blood-pressure system, basically similar to conventional ausculatory sphygmomanometers, employing a standard occluding cuff, a gas-pressure source, and a gas-pressure regulator and valve. An electrical output transducer senses cuff pressure, and a microphone positioned on the brachial artery under the occluding cuff monitors the Korotkoff sounds from this artery. The output signals present the conventional systolic and diastolic indices in a clear, graphical display. The complete system also includes an electronic timer and cycle-control circuit.

**How it's done:** The output of the microphone is fed through a solid-state amplifier and a 35-cps filter into the mixing circuitry where it is superimposed on the signal from the pressure transducer. The output of the mixing circuitry is fed to a continuous chart recorder which gives a plot of cuff pressure versus time. The first signal pulse appearing on the graph as the cuff pressure is slowly reduced indicates the systolic pressure and the last pulse corresponds to the diastolic pressure.

(continued overleaf)

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**Notes:**

1. The occluding cuff must be of a minimum width in order to ensure correlation of the measured systolic and diastolic values with the accepted indices. A narrow cuff is highly desirable for comfort and mobility of the subject.
2. Over 2,000 blood pressure measurements have been taken using this system on various individuals, and many of the readings have been compared with those taken with a conventional sphygmomanometer and stethoscope. In only a few instances were the readings off by more than a few millimeters of mercury.
3. A small amount of additional development would be required to make the system completely automatic. Such a system should be of considerable value for monitoring the blood pressure of hospitalized patients and as a clinical diagnostic aid.
4. Inquiries concerning this invention may be directed to:

   Technology Utilization Officer
   Manned Spacecraft Center
   P. O. Box 1537
   Houston, Texas, 77001
   Reference: B65-10365

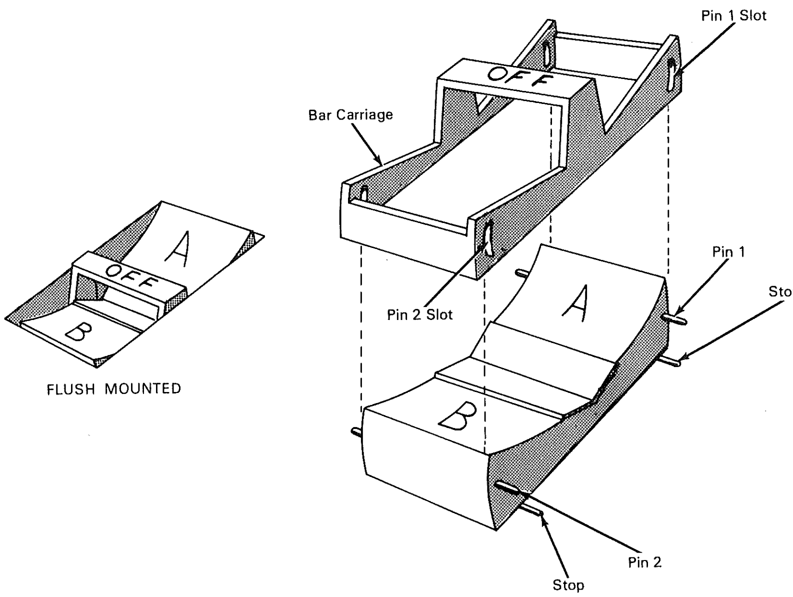
**Patent status:** NASA encourages the immediate commercial use of this invention. It is owned by NASA and inquiries about obtaining royalty-free rights for its commercial use may be made to NASA, Code AGP, Washington, D.C., 20546.

Source: The Garrett Corporation under contract
to Manned Spacecraft Center
(MSC-191)

December 1965 Brief 65-10376

# NASA TECH BRIEF

## Three-Position Rocker Switch Actuator Has Positive Centering



**The problem:** In certain activities, cumbersome gloves, sometimes pressurized as in high-altitude aircraft, limit the sense of touch of the operator who must use three position switches, such as toggle, rocker, or pushbutton. In this situation there is a danger of overriding the center position, which could have undesirable results.

**The solution:** A three-position rocker switch actuator that provides positive center positioning to inhibit possible override.

**How it's done:** When properly mounted to a three-position switch, the actuator is operated in the following manner. Depressing rocker tab A causes pin 1 to move downward in its slot and the pivoted rocker causes tab B to rise an amount equal to the downward travel of tab A. With pin 2 being normally at the top of its slot, the bar carriage rises at this end along with tab B. This action displaces the *off* bar upward by a slightly lesser amount and the switch is now positioned so that a circuit is controlled.

To control the second circuit and release the first, tab B is depressed and an action opposite to that described above takes place.

To return the switch to center position so both circuits are released, the *off* bar is pressed. In the case of tab A having been previously depressed, this applies pressure to pin 1 through the bar carriage and pin 2 slot to force tab B downward to its center or neutral position where its further downward movement is arrested by the stops.

(continued overleaf)

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**Note:** Switch position is visually identified by rocker position and functions can be shown on tabs and bar.

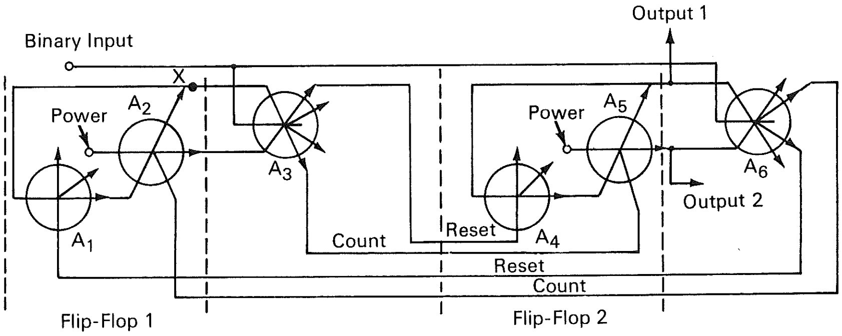
**Patent status:** Title to this invention has been waived under the provisions of the National Aeronautics and Space Act (42 U.S.C. 2457 (f)), to North American Aviation, Inc. 1700 East Imperial Highway, El Segundo, California.

Source: Robert L. Bogley of North American
Aviation, Inc., under contract to
Manned Spacecraft Center
(MSC-261)

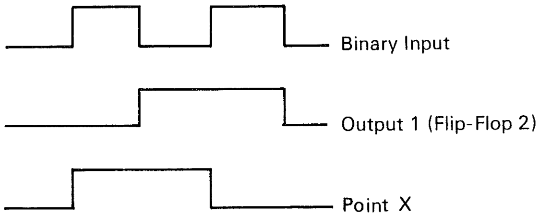
December 1965 Brief 65-10377

# NASA TECH BRIEF

## Binary Counter Uses Fluid Logic Elements



COUNTER SCHEMATIC



FLUID PULSE WAVEFORMS

**The problem:** To design a binary counter using fluid logic elements. Each stage of the counter must produce one output pulse for each two input pulses.

**The solution:** A binary-counter stage consisting of two fluid flip-flops, each of which contains three fluid logic elements. The binary output is taken from the output of the second flip-flop.

**How it's done:** Each flip-flop is constructed from a fluid amplifier ($A_2$,$A_5$) and a two-input, three-output element ($A_1$,$A_4$). The flip-flops are interconnected by the three-input, four-output elements ($A_3$,$A_6$). When the binary input is low (that is, when there is no fluid pulse), $A_3$ controls the state of flip-flop 2; when the binary input is high (that is, when there is a fluid pulse), $A_6$ controls the state of flip-flop 1.

Initially (that is, when there is no binary input), $A_3$ produces a reset pulse which does not affect flip-flop 2, since both flip-flops are in the reset state. When the binary input goes high, the $A_3$ reset is removed from flip-flop 2. Element $A_6$ produces a count pulse which switches flip-flop 1 into the count state. The count pulse from $A_3$ has no effect on flip-flop 2 because element $A_5$ has been locked on by $A_4$; therefore, flip-flop 2 remains in its initial state. When the binary input reverts to low, the count pulse from $A_3$ switches flip-flop 2 to its opposite state.

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When the binary input goes back to high, the $A_3$ count pulse is removed, and $A_6$ sends a reset pulse to flip-flop 1, switching its state. When the binary input goes back to low, $A_3$ sends a reset pulse to flip-flop 2, switching its state. In this way, the flip-flops switch their state once for every two changes in the binary input.

**Note:** Inquiries concerning this invention may be directed to:

Technology Utilization Officer
Marshall Space Flight Center
Huntsville, Alabama, 35812
Reference: B65-10377

**Patent status:** NASA encourages the immediate commercial use of this invention. Inquiries about obtaining rights for its commercial use may be made to NASA, Code AGP, Washington, D.C., 20546.

Source: UNIVAC Division of Rand Corporation
under contract to
Marshall Space Flight Center
(M-FS-323)

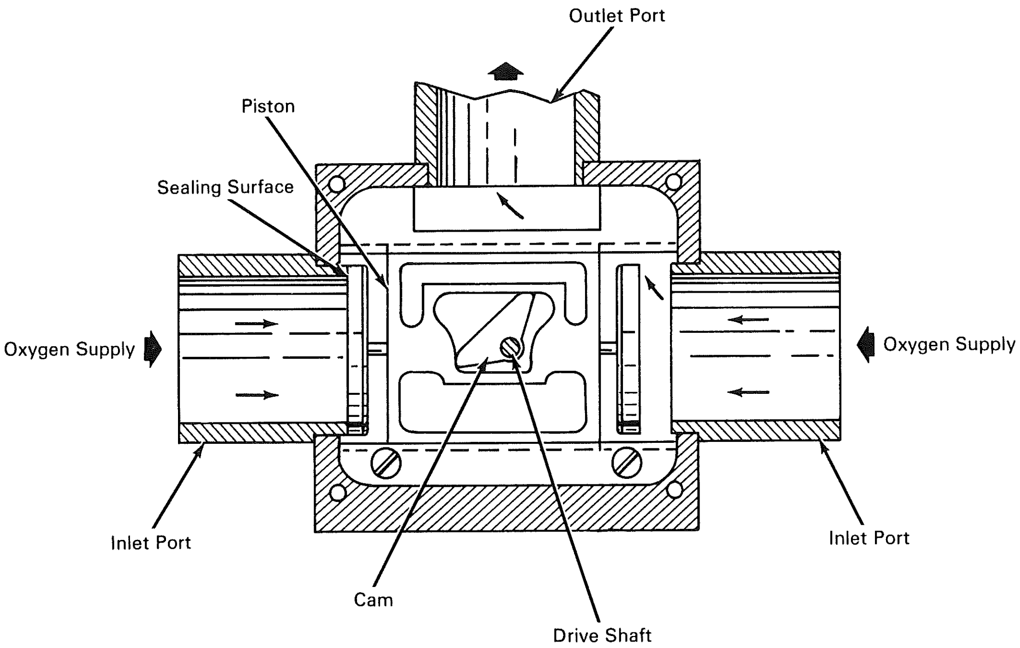
December 1965

Brief 65-10369

# NASA TECH BRIEF

NASA Tech Briefs are issued by the Technology Utilization Division to summarize specific technical innovations derived from the space program. Copies are available to the public from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia, 22151.

## Respiratory Transfer Valve Has Fail-Safe Feature



**The problem:** To design a quick-acting, remote-controlled valve that will connect either one of two oxygen or air supplies to a breathing tube. The valve must be fail-safe; that is, if there is a malfunction in the mechanism for operating the valve, one or both of the gas supplies must remain connected to the breathing tube. In addition, the valve must offer a low resistance to breathing and be capable of operating at a pressure differential of 5 psi when subjected to omnidirectional accelerations up to 20g.

**The solution:** A valve incorporating a cammed piston arrangement that is driven by a remote-controlled reversible rotary solenoid or reversible electric motor to connect either one of two oxygen (or air) supplies to a breathing tube.

**How it's done:** The valve chamber is fitted with two inlet ports, which are connected to separate oxygen supplies, and an outlet port, which is connected to a breathing tube. The chamber is preferably made of transparent plastic to permit visual inspection of the valve interior.

When the shaft, which is connected to a rotary drive mechanism, is rotated counterclockwise, the cam drives the piston to the left, thus sealing the left-hand port from one oxygen supply and opening the right-hand port to the second oxygen supply. Conversely,

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the left-hand port is opened and the right-hand port is closed when the shaft is rotated clockwise. Once either port is closed, the rotary drive mechanism may be switched off and the closed port will remain closed until the mechanism is again switched on. If the drive mechanism malfunctions during a switching operation, both inlet ports will be partially open, allowing an uninterrupted flow of oxygen to the outlet port.

## Notes:

1. This valve should find application in basal metabolism equipment or other clinical respiratory equipment requiring remote, fail-safe operation.
2. Inquiries concerning this invention may be directed to:

Technology Utilization Officer
Ames Research Center
Moffett Field, California, 94035
Reference: B65-10369

**Patent status:** NASA encourages the immediate commercial use of this invention. It is owned by NASA, and patent application has been filed. When patented, royalty-free non-exclusive licenses for its commercial use will be available. Inquiries concerning license rights should be made to NASA, Code AGP, Washington, D.C., 20546.

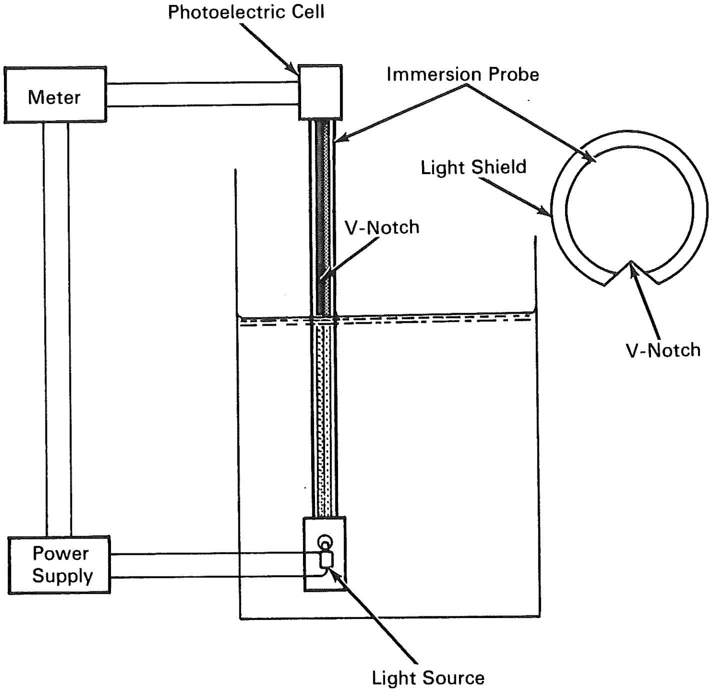
Source: Albert A. Puccinelli and
Joseph R. Smith, Jr.
(ARC-1)

December 1965

Brief 65-10382

# NASA TECH BRIEF

## Photoelectric System Continuously Monitors Liquid Level



**The problem:** To devise a simple photoelectric system for continuously monitoring the level of a transparent liquid in a tank. The system must operate automatically without moving parts and provide output signals to a remote recorder.

**The solution:** A system employing an immersion probe that presents a depth-sensitive optical transmission path between a light source and a photoelectric cell.

**How it's done:** The system consists of a light source, a light-transmitting rod or probe, a photoelectric cell, a power supply, and a readout meter, A longitudinal V-notch cut into the probe is roughened (like a ground-glass surface) to provide a lateral light-leakage path when the notched surface is wet by the liquid. An internally polished shield prevents leakage of extraneous light from or into the probe.

The amount of light leaking out of the notch depends on the depth and optical properties of the liquid in the tank. The amount of light which does not leak through the notch and is therefore transmitted to the photoelectric cell will increase as the liquid level falls. The light intensity detected by the photoelectric cell is thus a quantitative function of liquid level which can be read out on a calibrated meter.

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**Note:** Inquiries concerning this invention may be directed to:

Technology Utilization Officer
Marshall Space Flight Center
Huntsville, Alabama, 35812
Reference: B65-10382

**Patent status:** NASA encourages the immediate commercial use of this invention. It is owned by NASA and inquiries about obtaining royalty-free rights for its commercial use may be made to NASA, Code AGP, Washington, D.C., 20546.

Source: The Boeing Company under contract to
Marshall Space Flight Center
(M-FS-417)

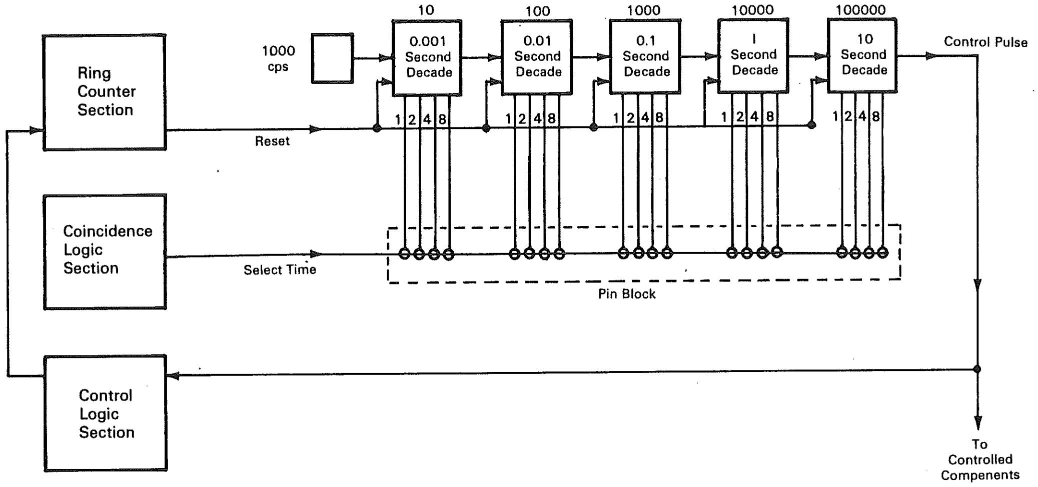
December 1965

Brief 65-10399

# NASA TECH BRIEF

NASA Tech Briefs are issued by the Technology Utilization Division to summarize specific technical innovations derived from the space program. Copies are available to the public from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia, 22151.

## Binary Counter Accumulates Time by Complementary Preset



**The problem:** To reduce the number of logic elements required to furnish electrical control functions for automatic sequential selection, rate, and operating period for any one or all of a given set of components. Previous methods have involved decade counters, coincident comparators, summing circuits, and *AND* gates to develop a control pulse.

**The solution:** A binary counter that is automatically preset to the complement of the desired time increment in milliseconds. An output pulse is produced each time the counter reaches its capacity.

**How it's done:** The basic unit consists of five standard decade counters connected in series. It is driven by a 1000 cps signal and is graduated in decade increments of 0.001, 0.01, 0.1, 1.0, and 10 seconds so that its accumulated counting capacity is 100 seconds or 100,000 milliseconds. A preset time input, consisting of the complement of the desired time increment in milliseconds, is generated by the coincidence logic section and fed to the counters via the pin board. Thus, if the desired time interval is 11 milliseconds, the counter would be preset to 99,989. When the counter counts to 100,000, the output from the final decade, a control pulse, is fed simultaneously to the control logic section and to the controlled components. The control logic section advances the ring counter to reset all decade counters to zero in preparation for the next preset time from the coincidence logic section. The control pulse to a controlled component closes a relay, snaps a solenoid, or performs other desired functions timed as to sequential selection, rate, and period as dictated by the coincidence logic input.

**Notes:**

1. This innovation should be useful in the operation of automated systems where a sequence of events must take place at different rates and for different time increments.

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2. Inquiries concerning this invention may be directed to:

Technology Utilization Officer
Manned Spacecraft Center
P.O. Box 1537
Houston, Texas, 77001
Reference: B65-10399

**Patent status:** NASA encourages the immediate commercial use of this invention. Inquiries about obtaining rights for its commercial use may be made to NASA, Code AGP, Washington, D.C., 20546.

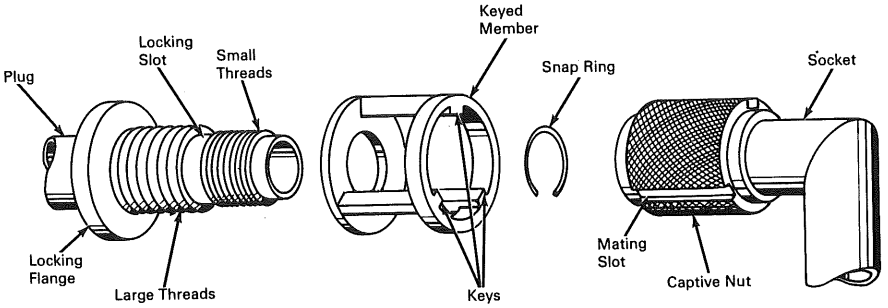
Source: Guy E. Marriner of
North American Aviation, Inc.,
under contract to
Manned Spacecraft Center
(MSC-242)

December 1965 Brief 65-10381

# NASA TECH BRIEF

NASA Tech Briefs are issued by the Technology Utilization Division to summarize specific technical innovations derived from the space program. Copies are available to the public from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia, 22151.

## Keyed Plugs and Sockets Prevent Improper Connections



**The problem:** In the connection of multiples of plugs and sockets in an electrical system of mating assemblies it is necessary that the right plug be mated with the right socket in each case to avoid damage to or malfunction of equipment. Color coding, especially in hard-to-get-at places where vision is obscured or blocked, is not entirely adequate.

**The solution:** Plugs and mating sockets that are individually keyed so that no plug can be mated with other than its proper matching socket.

**How it's done:** The connector consists of a plug, keyed member, snap ring, and socket. The keyed member slips over the small threads of the plug but is stopped against the large threads where it is held in place by the lock ring in the slot. The socket is equipped with a captive nut that is slotted to match the three keys of the keyed member. The plug and socket cannot be joined until the mating slots of the captive nut slide over the keys of the keyed member sufficiently for the small threads of the plug and the threads of the captive nut to become engaged. When the captive nut has been drawn up tight (the keyed member revolves with it), the locking flange is then drawn up on the large threads of the plug until it bears against the keyed member and effectively locks the assembly together.

**Note:** This device may be useful in automotive or aircraft applications where precise multiple connections must be made.

**Patent status:** Title to this invention has been waived under the provisions of the National Aeronautics and Space Act (42 U.S.C. 2457 (f)), to McDonnell Aircraft Corporation, Box 516, St. Louis, Missouri, 63166.

Source: Don L. Buckey and Harold Lankford
of McDonnell Aircraft Corporation
under contract to Manned Spacecraft Center
(MSC-231)
Category 01

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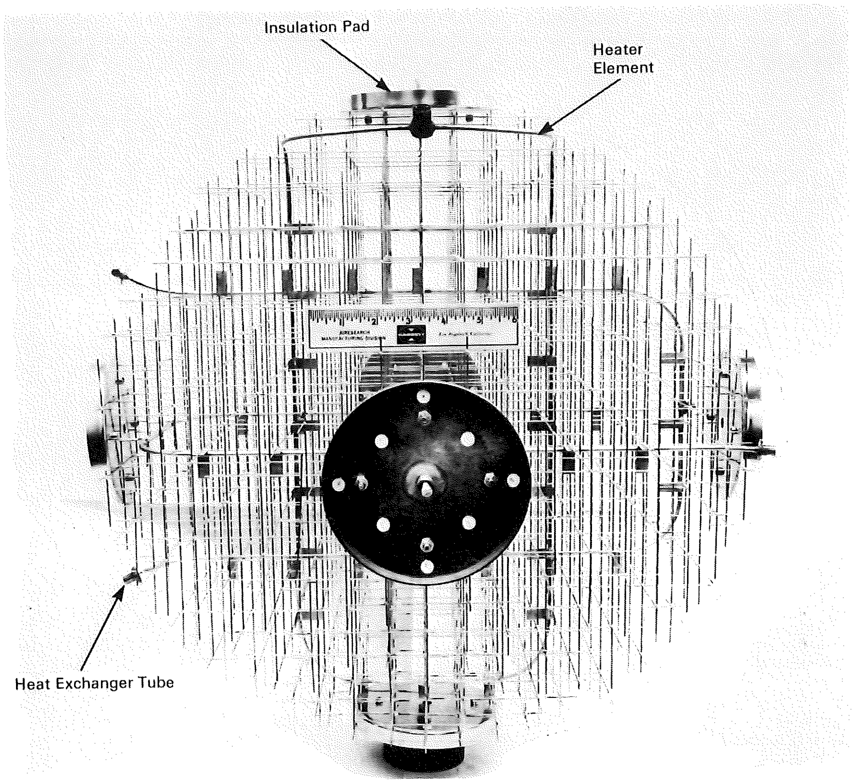
December 1965

Brief 65-10379

# NASA TECH BRIEF

## Three-Dimensional Wire-Mesh Capacitor System Measures Fluid Density



**The problem:** To devise an instrument that will automatically measure the bulk density of a stored, electrically nonconductive fluid containing varying proportions of liquid and vapor.

**The solution:** A gaging system employing a three-dimensional wire-mesh capacitor whose capacitance varies with the bulk density of the fluid dielectric medium between the capacitor "plates".

**How it's done:** Each of the two "plates" of the capacitor consists of a cubical array of electrically interconnected wires. The wires comprising one of the cubical arrays are orthogonal to and electrically isolated from the wires in the other array. The two capacitor "plates" thus formed are kept at the proper spacing (1.25 inches between individual wires) by insulating pads attached (on one face) at the ends of the principal axes of the intermeshed cubical array and

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(on the other face) to the inner wall of the fluid storage vessel. Electrical leads to a capacitance measurement circuit and readout device are connected to each of the two capacitor plates. The scale of the readout device is calibrated to indicate the bulk density of the fluid (which is dependent on the proportion of gas and liquid) in the vessel.

**Notes:**

1. For application in a subcritical oxygen storage system, advantage was taken of the extended heat-transfer surface of the density gage by attaching electrical heating elements and heat exchanger tubing to the grounded side of the wire arrays. These heat supplies were used to maintain the desired operating pressure inside the storage vessel.
2. Inquiries concerning this innovation may be directed to:

   Technology Utilization Officer
   Western Operations Office
   150 Pico Boulevard
   Santa Monica, California, 90406
   Reference: B65-10379

**Patent status:** NASA encourages commercial use of this innovation. No patent action is contemplated by NASA.

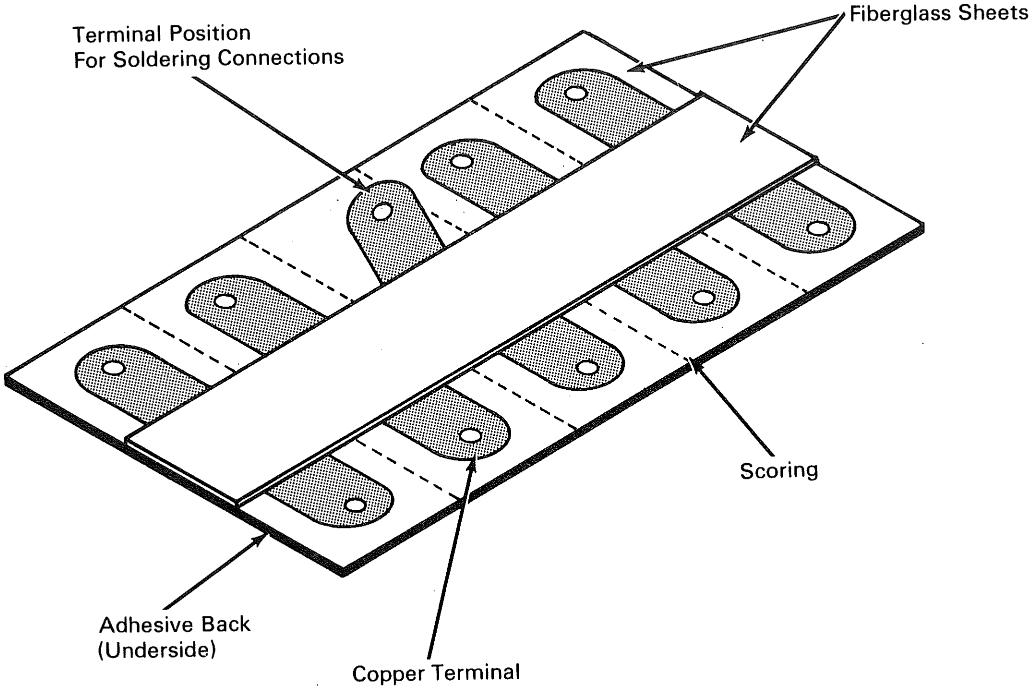
Source: The Garrett Corporation
under contract to
Western Operations Office
(WOO-194)

December 1965 Brief 65-10396

# NASA TECH BRIEF

NASA Tech Briefs are issued by the Technology Utilization Division to summarize specific technical innovations derived from the space program. Copies are available to the public from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia, 22151.

## Adhesive-Backed Terminal Board Eliminates Mounting Screws



**The problem:** Designing a terminal board for use in dense electronic circuits where mounting space and working space are limited, and where it may be undesirable or impractical to use mounting screws or other hardware fasteners.

**The solution:** Provide low-profile terminal boards which have a thin layer of pressure-sensitive adhesive backing.

**How it's done:** The terminal board consists of 0.012-inch-thick copper terminal strips cemented between 0.032-inch-thick fiberglass sheets. Scoring between terminal pairs facilitates detachment of the required number of terminals for specific applications. The copper terminals are bent outward for soldering of connections. The boards are mounted by pressing the adhesive backing onto a mounting surface in the equipment package.

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**Note:** Inquiries concerning this invention may be directed to:

Technology Utilization Officer
Manned Spacecraft Center
P.O. Box 1537
Houston, Texas, 77001
Reference: B65-10396

**Patent status:** NASA encourages the immediate commercial use of this invention. It is owned by NASA and inquiries about obtaining royalty-free rights for its commercial use may be made to NASA, Code AGP, Washington, D.C., 20546.

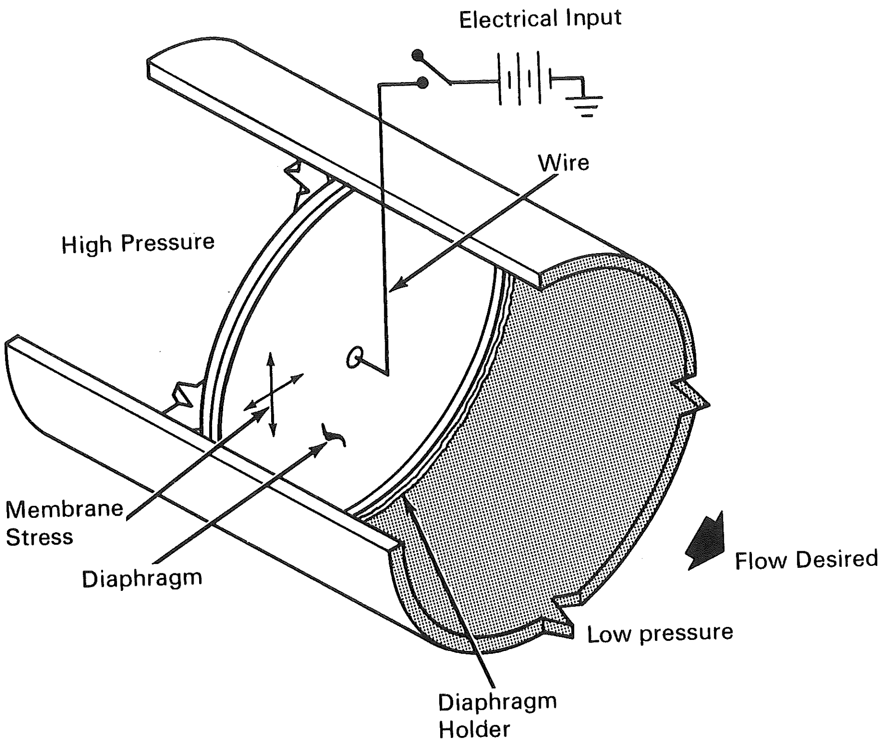
Source: North American Aviation, Inc.
under contract to
Manned Spacecraft Center
(MSC-173)

December 1965

Brief 65-10400

NASA TECH BRIEF

# Electrically Heated Diaphragm Eliminates Use of Pyrotechnics



**The problem:** In certain systems it is necessary to contain fluids under pressure until a certain pressure threshold or point in time has been reached when the fluids are to be automatically released, often remotely. In the past, the most frequent method has employed pyrotechnics that are dangerous in some applications and have proven unreliable at times due to misfires.

**The solution:** A membrane-type diaphragm that is resistance heated until its strength is degraded to the point of rupture, thus releasing the contained fluid.

**How it's done:** At the appropriate point in time or pressure, electrical energy in the form of resistance heating is applied to the downstream surface of a burst diaphragm. The electrical energy, applied to the diaphragm under membrane stress, is sufficient to degrade the strength of the diaphragm so that it ruptures and releases the pressurized gas or liquid that it had restrained.

**Notes:**

1. This innovation could be applied in deep submergence vehicles, oil field instrumentation and formation survey equipment, and hydraulic cooling and fuel systems.

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2. Inquiries concerning this innovation may be directed to:

   Technology Utilization Officer
   Manned Spacecraft Center
   P.O. Box 1537
   Houston, Texas, 77001
   Reference: B65-10400

**Patent status:** NASA encourages commercial use of this innovation. No patent action is contemplated by NASA.

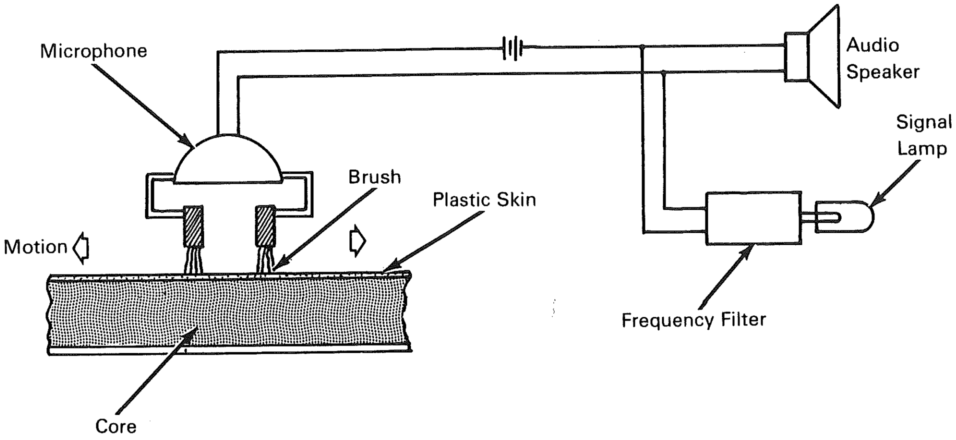
Source: Robert C. Mathewson of North
American Aviation, Inc., under
contract to Manned Spacecraft Center
(MSC-241)

December 1965

Brief 65-10380

# NASA TECH BRIEF

## Device Detects Unbonded Areas In Plastic Laminates



**The problem:** To develop a nondestructive quality-control method for detecting unbonded or delaminated areas in plastic laminates.

**The solution:** A device that generates an acoustic signal whose frequency changes in the presence of delaminated or weakly bonded areas in the laminate are picked up by a microphone.

**How it's done:** The acoustic device consists of a circular metallic brush which is moved laterally across the laminated surface. This motion produces a scratching sound which changes in frequency as the brush encounters a change in bonding characteristics. The sound is picked up by a small microphone connected to a speaker which gives an audible indication of the frequency change. The microphone output can also be fed to a filter which passes only frequencies associated with defective areas to actuate a signal light.

**Notes:**

1. The device was originally designed to detect unbonded areas between 0.004″- to 0.010″-thick plastic skins and glass fiber reinforced foam cores. It could, however, be applied to other laminated structures having thicker skins (plastic or metallic) and other core materials by modifying the stiffness and shape of the metallic brush and by changing the pass band of the frequency filter.

2. Inquiries concerning this invention may be directed to:

Technology Utilization Officer
Western Operations Office
150 Pico Boulevard
Santa Monica, California, 90406
Reference: B65-10380

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**Patent status**: NASA encourages the immediate commercial use of this invention. Inquiries about obtaining rights for its commercial use may be made to NASA, Code AGP, Washington, D.C., 20546.

Source: Douglas Aircraft Company, Inc.
under contract to
Western Operations Office
(WOO-206)

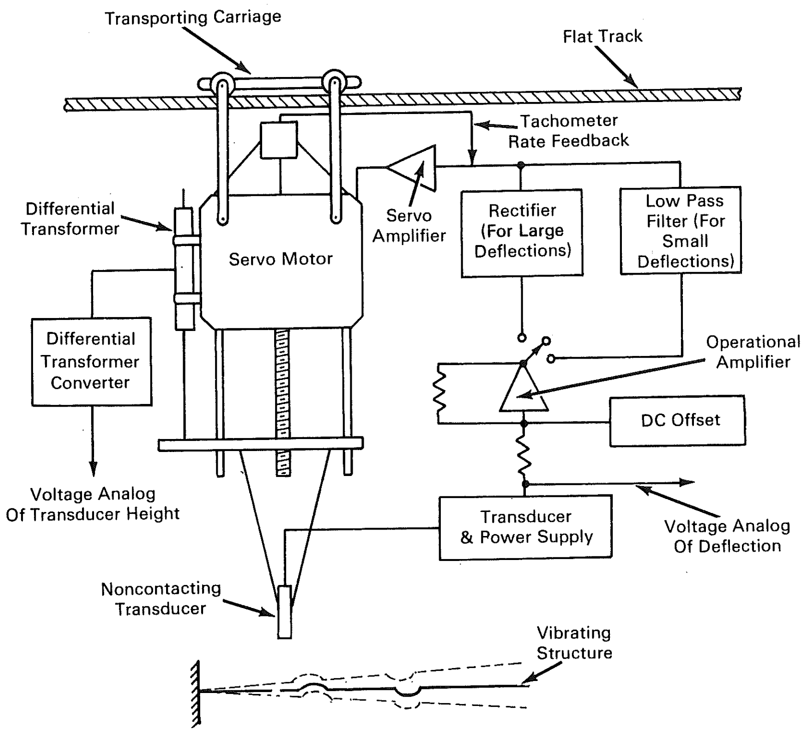
December 1965

Brief 65-10392

# NASA TECH BRIEF

NASA Tech Briefs are issued by the Technology Utilization Division to summarize specific technical innovations derived from the space program. Copies are available to the public from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia, 22151.

## Noncontacting Vibration Transducer Has Constant Sensitivity


Transporting Carriage
Flat Track
Tachometer Rate Feedback
Differential Transformer
Servo Amplifier
Rectifier (For Large Deflections)
Low Pass Filter (For Small Deflections)
Servo Motor
Differential Transformer Converter
Operational Amplifier
DC Offset
Voltage Analog Of Transducer Height
Transducer & Power Supply
Voltage Analog Of Deflection
Noncontacting Transducer
Vibrating Structure

**The problem:** To devise an instrument of constant sensitivity using a noncontacting transducer for automatically measuring the vibration amplitudes (deflections) along the span of a vibrating structure of irregular contour. Previous instruments for measuring vibration amplitudes in this type of structure not only required the use of profile guides and manual adjustments to keep the noncontacting transducer at a fixed average distance from the vibrating surface, but also had a very limited amplitude range. In addition, it was impossible to fabricate profile guides when the structures were subject to nonpredictable deformations.

**The solution:** A system employing a feedback control (servo loop) to position the noncontacting vibration transducer at a constant height above the test surface. A differential transformer is incorporated to facilitate calibration and extend the amplitude range of the system. Except for the transporting carriage, all components of the system are standard commercially available items.

**How it's done:** The noncontacting transducer is physically connected to the servo motor, which is moved along the span of the test structure by the trans-

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porting carriage. The initial height of the transducer above a fixed point on the static test surface is set by manually adjusting the dc offset to produce a zero voltage at the input to the operational amplifier. Any change in height of the transducer will then result in a dc voltage component from the transducer to the operational amplifier which will cause the servo motor to reposition the transducer to its initial height. The transducer will thus be constrained to follow the contour of the test structure as the transporting carriage moves along the track. The ac voltage output from the transducer, which is an analog of the vibration amplitude of the test structure at the point of measurement, is passed to a convenient readout device.

When vibration amplitudes are less than 0.1 inch, the output from the operational amplifier is connected to the low-pass filter (5-cps cutoff) to block vibration signals from the transducer. Rate feedback generated by the tachometer suppresses oscillations in the feedback control system.

Large vibration amplitudes, up to one inch, are measured by making the noncontacting transducer follow the envelope of the vibration signal. In order to accomplish this, the low-pass filter is replaced by the rectifier, and the voltage output is obtained from the differential transformer converter. Vibration amplitudes of this magnitude require two consecutive sweeps and plots of the test surface, one sweep and plot for the static condition and one for the vibrating condition. The point-by-point differences between the two plots are proportional to the vibration amplitudes.

## Notes:

1. The transporting carriage was designed to move the noncontacting transducer automatically in equal adjustable steps over a 20-inch span of a vibrating test panel.
2. Inquiries concerning this invention may be directed to:

Technology Utilization Officer
Langley Research Center
Langley Station
Hampton, Virginia, 23365
Reference: B65-10392

**Patent status:** NASA encourages the immediate commercial use of this invention. It is owned by NASA and inquiries about obtaining royalty-free rights for its commercial use may be made to NASA, Code AGP, Washington, D.C., 20546.

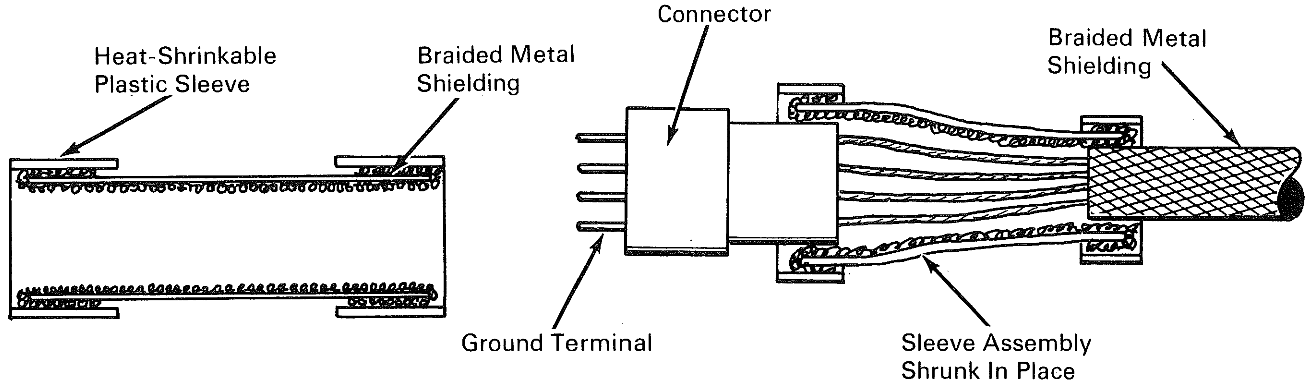
Source: Bruce Flagge
(Langley-99)

December 1965 Brief 65-10387

# NASA TECH BRIEF

NASA Tech Briefs are issued by the Technology Utilization Division to summarize specific technical innovations derived from the space program. Copies are available to the public from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia, 22151.

## Shrinkable Sleeve Eliminates Shielding Gap in RF Cable



**The problem:** To eliminate the RF shielding gap between an RF cable (with braided-metal RF shielding) and a multipin connector. In order to wire a shielded cable to the connector, it is necessary to remove one or more inches of the shielding. A grounding jumper across the gap between the terminated portion of the braided metal and connector, which is commonly used, does not provide adequate RF shielding across the gap.

**The solution:** An easily installed sleeve assembly between the connector and the terminated portion of the metal shielding.

**How it's done:** The sleeve assembly consists of a short length of braided metal enclosed in a heat-shrinkable plastic sleeve. The assembly is slipped over the terminated end of the cable and the base of the connector. Heat is then applied to shrink the plastic sleeve and force the inner metal braiding tightly around the mating components, thus forming a continuous RF shield. The sleeve assembly can be easily removed when necessary.

**Notes:**

1. This device may be used at any section of an RF harness where a shielding gap exists.
2. Inquiries concerning this innovation may be directed to:

   Technology Utilization Officer
   Western Operations Office
   150 Pico Boulevard
   Santa Monica, California, 90406
   Reference: B65-10387

**Patent status:** NASA encourages commercial use of this innovation. No patent action is contemplated by NASA.

Source: General Dynamics/Convair Corporation
under contract to
Western Operations Office
(WOO-207)
Category 01

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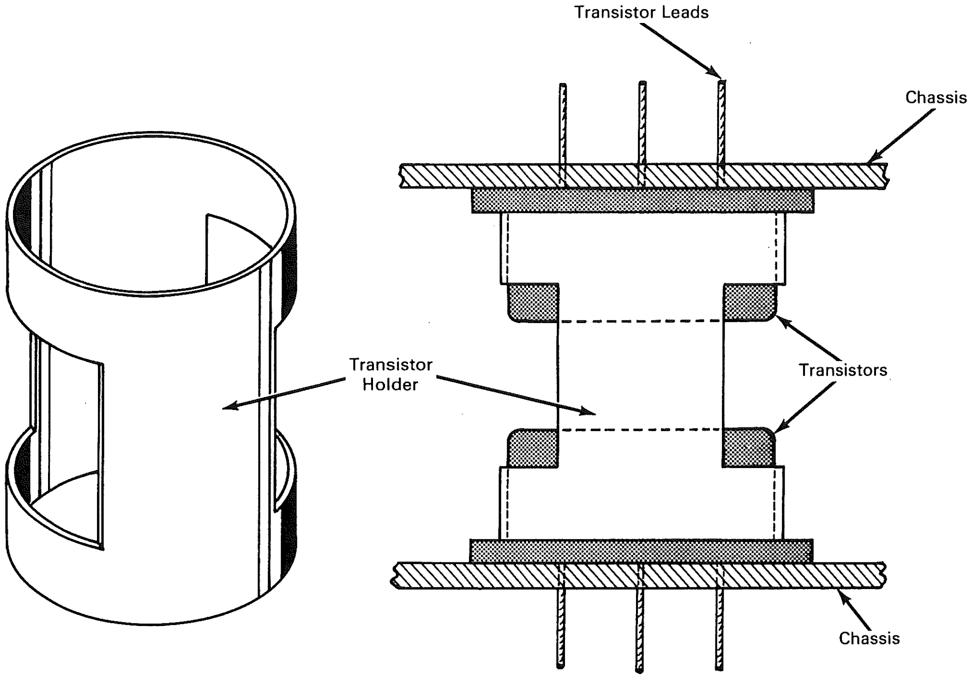
December 1965

Brief 65-10389

# NASA TECH BRIEF

NASA Tech Briefs are issued by the Technology Utilization Division to summarize specific technical innovations derived from the space program. Copies are available to the public from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia, 22151.

## Insulator-Holder Protects Transistors in Dense Electronic Assemblies



SIDE VIEW OF HOLDER WITH TWO TRANSISTORS

**The problem:** To devise an insulated holder for mounting metal-case transistors in a chassis containing densely packed electronic components. The holder must insulate against electrical shorts between adjacent transistors, absorb some of the pressure exerted during spot welding operations, and prevent the formation of thermally insulating air cavities around the transistors when the electronic assembly is encapsulated with potting resin.

**The solution:** A molded insulating spacer which contains one or more cavities conforming to the shape of the transistor case.

**How it's done:** The cylindrical holder shown in the illustration accommodates two transistors back-to-back in close-fitting cavities on either end of the holder. The transistors are mechanically supported on their bases and electrically isolated from each other by the holder. An opening extending laterally

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through the holder allows potting resin to fill the gap between the transistors. The holders require little more space than the transistors themselves.

**Notes:**

1. This type of holder may be used for insulation and support of other circuit components.
2. Inquiries concerning this invention may be directed to:

Technology Utilization Officer
Manned Spacecraft Center
P.O. Box 1537
Houston, Texas, 77001
Reference: B65-10389

**Patent status:** NASA encourages the immediate commercial use of this invention. It is owned by NASA and inquiries about obtaining royalty-free rights for its commercial use may be made to NASA, Code AGP, Washington, D.C., 20546.

Source: Westinghouse Electric Corporation
under contract to
Manned Spacecraft
Center (MSC-214)